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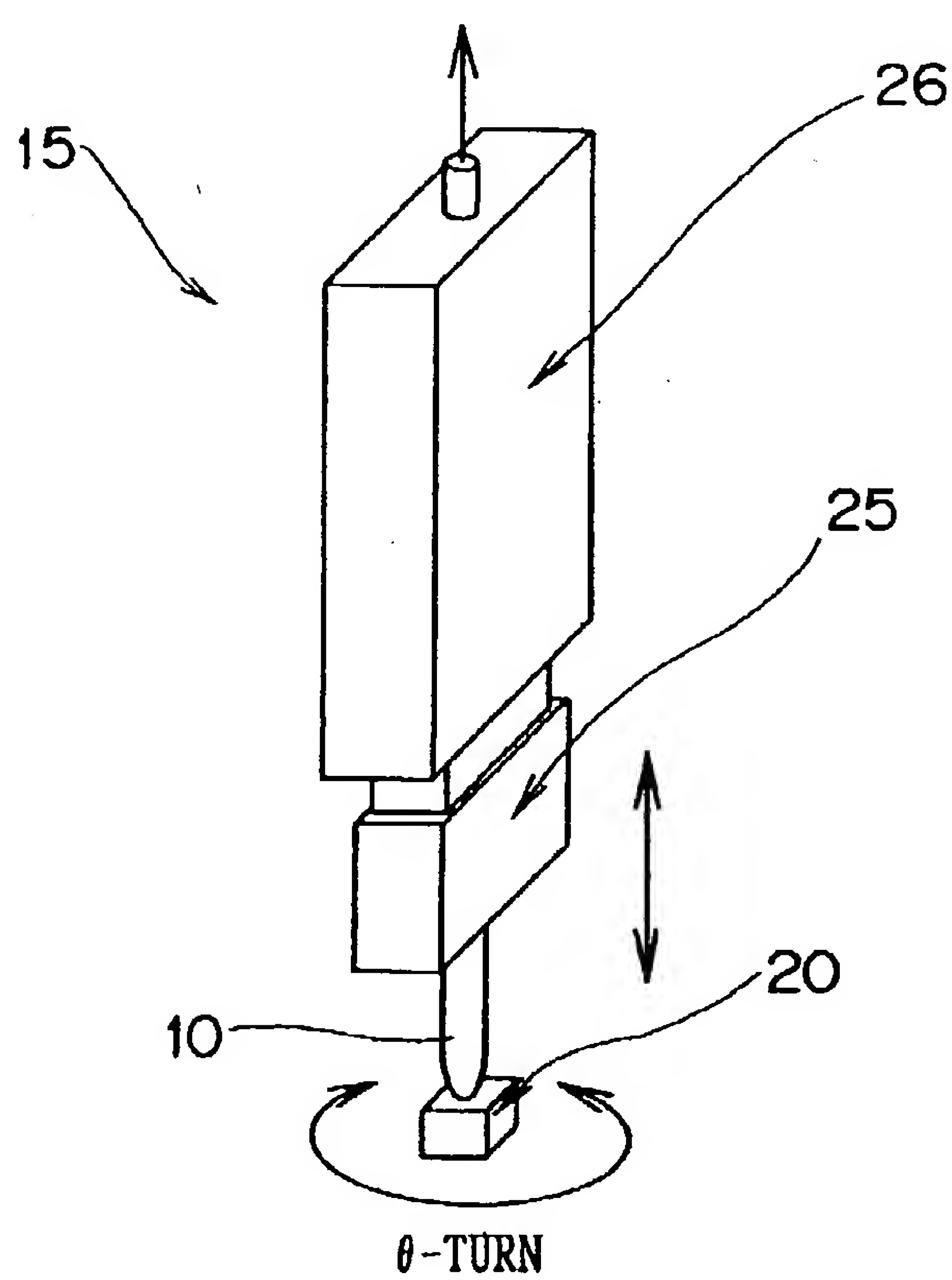
(54) **Title:** COMPONENT SUCTION DEVICE, COMPONENT MOUNTING APPARATUS AND COMPONENT MOUNTING METHOD



(57) **Abstract:** The component suction device includes a suction nozzle (10) for sucking and holding a component (20), a nozzle turning device (25) for holding the suction nozzle and turning the suction nozzle, and a nozzle up-and-down device (26) which is located upward of the nozzle turning device and which is connected to the suction nozzle to serve for moving up and down the suction nozzle along an axial direction of the suction nozzle.

Fig. 26

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DESCRIPTION

COMPONENT SUCTION DEVICE, COMPONENT MOUNTING APPARATUS AND COMPONENT MOUNTING METHOD

Technical Field

The present invention relates to a component suction device for sucking up and holding a component, which is to be mounted onto a circuit-forming body such as a board, and then turning the component to its mounting-posture angle before mounting the component onto the circuit-forming body, also to a component mounting apparatus equipped with the component suction device, and further to a component mounting method for sucking up and holding a component, which is to be mounted onto a circuit-forming body such as a board, and then turning the component to its mounting-posture angle before mounting the component onto the circuit-forming body.

Background Art

As this type of component suction device, those of various structures have been known conventionally. For example, as shown in Fig. 22, there has been provided a component mounting apparatus equipped with a mounting head 307 having as component suction devices, for example, ten nozzles 304 that are made turnable all together and

selectively up-and-down movable. This mounting head 307 is moved to the component feed device side, sucking and holding components from component feed positions of individual component cassettes of component supply devices, then moves to a recognition device to recognize the postures of the sucked-and-held components. Thereafter, the mounting head 307 moves to the board onto which the components are to be mounted, and based on the recognition result, mount the components at mounting positions of the board.

In this case, the mounting head 307 is so designed that for adjustment of the turning postures of components by turning the individual nozzles 304 about their axes, and the ten nozzles 304, …, 304 are simultaneously turned to the same angle by driving one turn-actuating motor 311. Also, for suction and mounting of components, only specified nozzles 304 out of the ten nozzles 304, …, 304 are selectively moved down to a specified extent by driving cylinders 310 based on the switching of valves so as to be protruded lower than the other nozzles, and then the whole mounting head 307 is moved down by the drive of a up-and-down motor 312.

However, with component suction devices of the above structure, there has been a demand for making it possible to turn the nozzles independently of one another in the case where further shorter mounting cycle time is

desired. That is, when the nozzles are turned after component recognition and before component mounting, all the nozzles need to be turned at once to a correction angle of a nozzle holding a component which is to be next mounted, and after the mounting with the nozzle, all the nozzles need to be turned at once to a correction angle of a nozzle holding a component which is to be next mounted, followed by mounting with the nozzle. Thus, it has been the case that mounting operation is enabled only after each nozzle is turned and corrected. It has been impossible to turn all the nozzles to their respective desired angles at the same timing.

Therefore, an object of the present invention is to solve the above-described issues and provide a component suction device capable of turning a plurality of component suction nozzles individually up and down and about their axes, respectively.

Disclosure Of Invention

In accomplishing these and other aspects, according to a first aspect of the present invention, there is provided a component suction device for sucking a component which is to be mounted onto a circuit-forming body, comprising:

a suction nozzle for sucking and holding the

component;

a nozzle turning device for holding the suction nozzle and turning the suction nozzle; and

a nozzle up-and-down device which is located upward of the nozzle turning device and which is connected to the suction nozzle to serve for moving up and down the suction nozzle along an axial direction of the suction nozzle.

According to a second aspect of the present invention, there is provided a component suction device according to the first aspect, wherein the nozzle up-and-down device is implemented by an up-and-down linear motor for moving up and down the nozzle turning device along the axis of the suction nozzle, and wherein the nozzle turning device is moved up and down by driving the up-and-down linear motor, whereby the suction nozzle is moved up and down along the axis of the suction nozzle.

According to a third aspect of the present invention, there is provided a component suction device according to any one of the first to third aspects, wherein a coil is up-and-down movable relative to a magnetic-circuit forming member fixed to a mechanism forming member of the linear motor and wherein the nozzle turning device is fixed to a support member that supports the coil.

According to a fourth aspect of the present

invention, there is provided a component mounting apparatus comprising a mounting head having a plurality of component suction devices as described in any one of the first to third aspects, wherein

the nozzle turning devices of the plurality of component suction devices are driven individually and independently of one another, and the nozzle up-and-down devices of the plurality of component suction devices are driven individually and independently of one another.

According to a fifth aspect of the present invention, there is provided a component mounting apparatus comprising:

a mounting head having a plurality of component suction devices as described in any one of the first to third aspects; and

a main controller for controlling operations of: turning components, which have been sucked and held by the suction nozzles, respectively, of the plurality of component suction devices, to placing posture angles of the individual components by drive of the nozzle turning devices; thereafter, recognizing postures of the individual components that have been sucked and held by the suction nozzles and turned to their placing posture angles; correcting the postures based on recognition results; and thereafter mounting the individual components onto the

circuit-forming body.

According to a sixth aspect of the present invention, there is provided a component mounting apparatus according to the fourth aspect, wherein the main controller controls to simultaneously turn the components sucked and held by the suction nozzles, respectively, to placing posture angles of the individual components by drive of the nozzle turning devices.

According to a seventh aspect of the present invention, there is provided a component mounting apparatus comprising:

a mounting head having a plurality of component suction devices as described in any one of the first to third aspects; and

a main controller for controlling operations of: simultaneously turning components, which have been sucked and held by the suction nozzles, respectively, of the plurality of component suction devices, to placing posture angles of the individual components by drive of the nozzle turning devices; thereafter, placing the individual components, which have been turned to their placing posture angles, onto the circuit-forming body.

According to an eighth aspect of the present invention, there is provided a component mounting apparatus comprising:

a mounting head having a plurality of component suction devices as described in any one of the first to third aspects; and

a main controller for controlling operation of: immediately after sucking and holding components by the suction nozzles of the plurality of component suction devices, turning the individual components to their respective placing posture angles by drive of the nozzle turning devices of the individual component suction devices individually and independently of one another; and thereafter placing the individual components, which have been turned to their placing posture angles, onto the circuit-forming body.

According to a ninth aspect of the present invention, there is provided a component mounting method for sucking and holding components, which are to be mounted onto a circuit-forming body, with a plurality of suction nozzles and thereafter placing the sucked and held components onto the circuit-forming body, the method comprising:

turning the individual components, which have been sucked and held respectively by the suction nozzles, to placing posture angles of the components individually and independently of one another;

thereafter, recognizing postures of the individual

components that have been sucked and held by the suction nozzles and turned to their respective placing posture angles; and

thereafter, correcting the postures based on recognition results and then placing the individual components onto the circuit-forming body.

According to a 10th aspect of the present invention, there is provided a component mounting method according to the ninth aspect, wherein in turning the individual components, which have been sucked and held respectively by the suction nozzles, to placing posture angles of the components individually and independently of one another, the components, which have been sucked and held respectively by the plurality of suction nozzles, are simultaneously turned to the placing posture angles of the individual components.

According to an 11th aspect of the present invention, there is provided a component mounting method according to the ninth aspect, wherein in turning the individual components, which have been sucked and held respectively by the suction nozzles, to placing posture angles of the components individually and independently of one another, the individual components are turned to their respective placing posture angles individually and independently of one another, immediately after the sucking

and holding of the components by the suction nozzles.

According to a 12th aspect of the present invention, there is provided a component mounting apparatus comprising:

a mounting head having a plurality of component suction devices as described in any one of the first to third aspects;

a main controller which is located on a component-mounting-apparatus main body and which controls component mounting operation;

a head controller which is located on the mounting head and connected to the main controller to perform one-to-one asynchronous communications in serial connection with the main controller in association with drive-control related information; and

a plurality of servo drivers which are located on the mounting head and connected to the head controller and which perform one-to-multi synchronous communications in serial connection with the head controller in association with drive-control related information and thus drive and control the nozzle up-and-down devices of the individual component suction devices based on resulted drive-control related information obtained from the head controller.

According to a 13th aspect of the present invention, there is provided a component mounting apparatus

according to the 12th aspect, wherein

the plurality of servo drivers have addresses different from one another; and

the drive-control related information comprises: drive-amount information containing addresses of the servo drivers, and information as to drive amounts for the nozzle up-and-down device or the nozzle turning device; and an operation start signal to be communicated at a timing different from that of the drive-amount information, wherein after the drive-control related information has been received by the servo drivers having the addresses, the servo drivers, upon receiving the operation start signal, exert control so that the nozzle up-and-down device or the nozzle turning device is driven based on the drive-amount information.

According to a 14th aspect of the present invention, there is provided a component mounting apparatus according to any one of the fourth to eighth aspects, wherein after the components are sucked and held by their corresponding suction nozzles of the plurality of component suction devices and before the component recognition is started, the individual nozzle up-and-down devices are driven to move the suction nozzles up and down so that bottom faces of the individual components are aligned.

According to a 15th aspect of the present

invention, there is provided a component suction device for sucking a component which is to be mounted onto a circuit-forming body, comprising:

a drive shaft which is up-and-down movable and rotatable about its axis;

a suction nozzle which is fitted at a lower end of the drive shaft so as to be relatively unturnable and up-and-down relatively immovable and which can suck and hold the component;

a θ-turn driving motor which is connected to an upper portion of the drive shaft so as to be up-and-down relatively movable and relatively unturnable and which turns the drive shaft about its axis; and

an up-and-down driver device which has a first coupling section connected to the drive shaft up-and-down relatively immovably and relatively turnably and which drives up and down the first coupling section to thereby drive the drive shaft up and down.

According to a 16th aspect of the present invention, there is provided a component suction device according to the 15th aspect, wherein the drive shaft is provided in a plural number and each of the drive shafts is equipped with the up-and-down driver device and the θ-turn driving motor, and wherein array pitches of the up-and-down driver devices and the θ-turn driving motors are equal to

an array pitch of the suction nozzles and further equal to an array pitch of a plurality of component feed sections of a component feed device which feeds the components to be sucked and held by the suction nozzles.

According to a 17th aspect of the present invention, there is provided a component suction device according to the 15th or 16th aspect, wherein the up-and-down driver device is a linear motor.

According to an 18th second aspect of the present invention, there is provided a component suction device according to any one of the 15th to 17th aspects, wherein the θ-turn driving motor is a brushless motor.

According to a 19th aspect of the present invention, there is provided a component suction device according to any one of the 15th to 18th aspects, further comprising a suction control valve for controlling suction operation of the nozzle.

According to a 20th aspect of the present invention, there is provided a component suction device according to the 18th aspect, wherein the brushless motor comprises:

a rotor which is supported so as to be axially turnable and which is magnetized to a plurality of poles peripherally; and a stator in which a fore end portion of teeth having a coil wound around a tooth winding portion is

opposed to an outer periphery of the rotor, so that the rotor is turned along with a rotating magnetic field of the stator, and wherein

the fore end portion of each of the teeth of the stator is shaped into a circular-arc surface extending along the outer periphery of the rotor, and the tooth winding portions are formed parallel to one another.

According to a 21st aspect of the present invention, there is provided a component suction device according to the 20th aspect, wherein in the brushless motor, the stator is so formed that the circular-arc surfaces of the fore end portions of the teeth confronting the outer periphery of the rotor have a symmetrical slot pitch.

According to a 22nd aspect of the present invention, there is provided a component suction device according to the 20th or 21st aspect, wherein in the brushless motor, the stator has a thickness along the axis of the rotor and has such a flat shape along an end face of the rotor that a first length formed by connecting 0° and 180° to each other about the axis is shorter than a second length formed by connecting 90° and 270° to each other.

According to a 23rd aspect of the present invention, there is provided a component suction device according to the 22nd aspect, wherein in the brushless

motor,

the flat-type stator is formed of first, second stator blocks which contact each other at a boundary of connection between the 0° and 180° about the axis.

According to a 24th aspect of the present invention, there is provided a component suction device according to the 23rd aspect, wherein in the brushless motor,

each stator block of the first stator block and the second stator is composed of a plurality of tooth blocks which are joined together so that a magnetic path is formed by base end portions of their tooth winding portions.

According to a 25th aspect of the present invention, there is provided a component suction device according to the 24th aspect, wherein in the brushless motor,

the flat-type stator is formed of a single stator block.

According to a 26th aspect of the present invention, there is provided a component suction device according to the 24th aspect, wherein in the brushless motor,

the flat-type stator has

grooves which serve as the tooth winding portion and which are formed thicknesswise in a side surface of the

stator crossing a direction of the first length, where

an outermost peripheral surface of the coil wound on the grooves is positioned so as to be flush with the side surface or inner than the side surface.

According to a 27th aspect of the present invention, there is provided a component suction device according to the 17th aspect, wherein the linear motor includes:

a plurality of frame coils provided inside a cylindrical outer yoke on a stationary side;

an inner yoke having a plurality of teeth in which a magnetic communicating portion is formed at at least one end so as to pass through the frame coils; and

magnets provided on both surfaces of each tooth so that teeth in which faces opposed to the frame coils have a single polarity adjoin to each other in polarity different from each other, where

a magnetic flux radiated from a specific magnet out of the magnets flows to an adjacent tooth via the outer yoke, passing through the magnetic communicating portion, and flowing through the tooth on which the specific magnet is provided, and thus flowing back to the specific magnet, and wherein

with an electric current supplied to the frame coil, a movable side composed of the magnets and the inner

yoke moves longitudinally of the teeth.

According to a 28th aspect of the present invention, there is provided a component suction device according to the 27th aspect, wherein in the linear motor, the inner yoke is U-shaped.

According to a 29th aspect of the present invention, there is provided a component suction device according to the 27th aspect, wherein in the linear motor, the frame coil has an opening face having such a rectangular shape that a length of its side line opposite to the magnet is longer than a length of its span section.

According to a 30th aspect of the present invention, there is provided a component suction device according to the 28th aspect, wherein the linear motor includes:

an inner yoke having a plurality of teeth in which a magnetic communicating portion is formed at at least one end thereof;

an outer yoke which externally surrounds the plurality of tooth;

magnets provided opposite to both faces of the teeth inside the outer yoke so that their faces of the magnets opposed to the teeth are of a single pole and the faces opposed to their respective adjoining teeth are different in polarity from each other;

coils wound on the individual teeth of the inner yoke;

a magnetic flux radiated from a specific magnet out of the magnets flows to an adjacent tooth via the outer yoke, passing through the magnetic communicating portion, and flowing through the tooth opposing the specific magnet, and thus flowing back to the specific magnet, and wherein

with an electric current supplied to the coil, a movable side composed of the magnets and the outer yoke moves in a longitudinal direction of the teeth.

According to a 31st aspect of the present invention, there is provided a component suction device according to the 30th aspect, wherein in the linear motor, the teeth each have such a rectangular shape that a length of its side line opposite to the magnet is longer than a length of a connection side connecting the opposite side lines to each other.

Brief Description Of Drawings

These and other aspects and features of the present invention will become clear from the following description taken in conjunction with the preferred embodiments thereof with reference to the accompanying drawings, in which:

Fig. 1 is a schematic perspective view of a

component suction device according to the first embodiment of the present invention;

Fig. 2 is an overall schematic perspective view of a component mounting apparatus on which the component suction device according to the first embodiment of the present invention is mounted;

Fig. 3 is a perspective view of a mounting head of the component mounting apparatus equipped with the component suction device;

Fig. 4 is a block diagram showing the relationship between the main controller, which is the control section of the component mounting apparatus, and other devices or members;

Figs. 5A and 5B are an exploded perspective view of the nozzle up-and-down device and a partial sectional view of the nozzle turning device in the component suction device;

Fig. 6 is a timing chart of X- and Y-direction moves of the mounting head, up-and-down operation and turning operation of the nozzles, and the like in the component mounting apparatus of the first embodiment;

Fig. 7 is a flowchart of X- and Y-direction moves of the mounting head, up-and-down operation and turning operation of the nozzles, or other mounting operations in the component mounting apparatus of the first embodiment;

Fig. 8 is a timing chart of X- and Y-direction moves of the mounting head, up-and-down operation and turning operation of the nozzles, and the like in the component mounting apparatus of the prior art;

Fig. 9 is a flowchart of X- and Y-direction moves of the mounting head, up-and-down operation and turning operation of the nozzles, or other mounting operations in the component mounting apparatus of the prior art;

Fig. 10 is an explanatory view showing a state in which bottom faces of components sucked and held by ten nozzles are adjusted to a specified height in the component mounting apparatus of the first embodiment;

Figs. 11A, 11B, and 11C are an explanatory view showing the relationship among the main controller, head controller, servo driver, motor, and memory, an explanatory view of information stored in a component database, and an explanatory view of component-feed-cassette arrangement data, respectively;

Fig. 12 is a flowchart of another example of X- and Y-direction moves of the mounting head, up-and-down operation and turning operation of the nozzles, or other mounting operations in the component mounting apparatus of the first embodiment;

Fig. 13 is an explanatory view of the control section composed of the main controller, the head

controller, the servo drivers, and the like in the component mounting apparatus of the first embodiment;

Fig. 14 is a schematic explanatory view of the control section composed of the main controller, the head controller, the servo drivers, and the like in the component mounting apparatus of the first embodiment;

Fig. 15 is a schematic explanatory view of the control section composed of a main controller, an NC board, servo drivers, and the like in the component mounting apparatus of the prior art;

Fig. 16 is a detailed explanatory view of the control section composed of the head controller, servo drivers, and the like in the component mounting apparatus of the first embodiment;

Figs. 17A and 17B are an explanatory view showing a state that adjustment to a recognition height H01 cannot be achieved at the component recognition by the mounting head, and an explanatory view showing a distortion occurring due to thermal changes of the nozzles or the like in representation of solid-line nozzle and dotted-line nozzle, respectively, in the component mounting apparatus of the prior art;

Fig. 18 is an explanatory view showing a state in which differences in component thickness are absorbed by contracting, to extents of component thickness differences,

springs provided for the individual nozzles of the mounting head, in the component mounting apparatus of the prior art;

Fig. 19 is an overall schematic perspective view of a component mounting apparatus with a component suction device mounted thereon according to a second embodiment of the present invention;

Fig. 20 is a partial perspective view of the component mounting apparatus of the Fig. 19;

Fig. 21 is a flowchart of X- and Y-direction moves of the mounting head, Y-axis direction move of the Y-table, up-and-down operation and turning operation of the nozzles, or other mounting operations in the component mounting apparatus of the second embodiment;

Fig. 22 is a perspective view of the prior-art mounting head;

Figs. 23A and 23B are explanatory views for explaining a placing-position shift during the turning of a nozzle in the cases where the nozzle is not subjected to effects of heat or the like and where it is, respectively;

Fig. 24 is a front view of a mounting head equipped with ten component suction devices according to a third embodiment of the present invention;

Fig. 25 is a perspective view of the component suction device of Fig. 24;

Fig. 26 is a partly sectional side view of the

component suction device of Fig. 24;

Fig. 27 is a front view of a drive shaft of the component suction device of Fig. 24;

Fig. 28 is a sectional view of a spline shaft part of the drive shaft of the component suction device of Fig. 24;

Fig. 29 is a partly sectional side view of the component suction device at the upper-end position of the nozzle in the component suction device of Fig. 24;

Fig. 30 is a partly sectional side view of the component suction device at the lower-end position of the nozzle in the component suction device of Fig. 24;

Fig. 31 is a front view of a voice coil motor of the component suction device of Fig. 24;

Fig. 32 is a left side view of the voice coil motor of the component suction device of Fig. 31;

Fig. 33 is a sectional view of the voice coil motor of the component suction device of Fig. 31, taken along the line B-B of Fig. 31;

Fig. 34 is a sectional view of the voice coil motor of the component suction device of Fig. 31, taken along the line A-A of Fig. 32;

Fig. 35 is a perspective view of the prior-art mounting head for explaining the life of bearings;

Figs. 36A and 36B are explanatory views of

turning operation of nozzles of the prior-art mounting head for explaining the life of bearings, respectively;

Fig. 37 is a perspective view of the mounting head of the third embodiment for explaining the life of bearings;

Figs. 38A and 38B are explanatory views of turning operation of a nozzle of the mounting head of the third embodiment for explaining the life of bearings, respectively;

Fig. 39 is an exploded perspective view of mechanical part of a brushless motor which is a first example of a θ-turn driving motor according to the third embodiment of the present invention;

Fig. 40 is a perspective view of the assembly of the first-example brushless motor of Fig. 39;

Fig. 41 is an enlarged sectional view of the first-example brushless motor of Fig. 39;

Fig. 42 is an enlarged sectional view showing a concrete configuration example of the first-example brushless motor of Fig. 39;

Fig. 43 is a perspective view of a stator of a brushless motor which is a second example of the θ-turn driving motor according to the third embodiment of the present invention;

Figs. 44A and 44B are an exploded perspective

view of a stator block of the brushless motor that is the third example of the θ-turn driving motor according to the third embodiment of the present invention, and an enlarged sectional view of the third example, respectively;

Fig. 45 is an explanatory view of a prior-art brushless motor;

Figs. 46A and 46B are explanatory views of a coreless brushless motor according to the prior art, respectively;

Fig. 47 is an exploded perspective view of a linear motor which is a first example of the up-and-down driver device according to the third embodiment of the present invention;

Fig. 48 is a perspective view showing an assembled state of the first-example linear motor;

Fig. 49 is an enlarged sectional view showing a part of an assembled state of the first-example linear motor;

Fig. 50 is an explanatory view showing a state of magnetic fluxes of the first-example linear motor;

Fig. 51 is an appearance perspective view of a linear motor which is a second example of the up-and-down driver device according to the third embodiment of the present invention;

Fig. 52 is an explanatory view showing a state of

magnetic fluxes of the second-example linear motor;

Fig. 53 is a plan view of a voice-coil type linear motor according to the prior art;

Fig. 54 is a plan view of a three-phase type linear motor according to the prior art; and

Fig. 55 is a side view of another example of the linear motor according to the prior art.

Best Mode for Carrying Out the Invention

Before the description of the present invention proceeds, it is to be noted that like parts are designated by like reference numerals throughout the accompanying drawings.

A component suction device 15 according to a first embodiment of the present invention is, as shown in Fig. 1, a component suction device for sucking up a component 20 which is to be mounted onto a circuit-forming body, for example, a board 2. The component suction device 15 includes a suction nozzle 10 for sucking and holding the component 20, a nozzle turning device 25 for holding the suction nozzle 10 and turning the suction nozzle 10, and a nozzle up-and-down device 26 which is disposed upper than the nozzle turning device 25 and connected to the suction nozzle 10 and which moves the suction nozzle 10 up and down along the axis of the suction nozzle 10.

The term "circuit-forming body" herein refers to circuit boards such as resin boards, paper-phenol boards, ceramic boards, glass epoxy boards, and film boards, circuit boards such as single-layer boards or multi-layer boards, and objects with circuits formed thereon such as components, casings, and frames. Also, the term "component" includes electronic components, mechanical components, optical components, and the like.

Fig. 2 shows an overall schematic perspective view of a component mounting apparatus which has two sets of mounting head 4 equipped with ten component suction devices 15, …, 15 as described above and which performs component mounting operation, and Fig. 3 shows a perspective view of the mounting head 4. This component mounting apparatus has two mounting sections, a front-side mounting section MU1 that is placed obliquely left-downward in Fig. 2 and a rear-side mounting section MU2 that is placed obliquely right-upward, where the individual mounting sections are enabled to perform component mounting operations such as component suction, recognition, and placement independently of one another to each board. It is noted that the component mounting operation refers to, for example, component suction, component carriage, component recognition, component placing operation and the like.

In Fig. 2, reference numeral 1 denotes a loader for carrying in a circuit board 2-0 (circuit boards are denoted by numeral 2 when referred to regardless of their positions, and boards of specific positions are denoted by numerals 2-0, 2-1, 2-2, 2-3 etc.), and numeral 11 denotes an unloader for carrying out the circuit board 2-3. Numeral 3 denotes a board carrying-and-holding device as an example of a circuit-forming-body holding device which is provided in each mounting section and which carries and holds the board 2 carried in from the loader 1, numeral 4 denotes a mounting head which is provided in each mounting section and has the component suction devices 15 and equipped with a plurality, for example, ten of component suction nozzles 10 that suck and hold the components 20, the component suction nozzles 10 being replaceable, numeral 5 denotes an X-Y robot 5 which is provided in each mounting section and which positions the mounting head 4 to a specified position in the X- and Y-directions, which are two perpendicular directions within the component-mounting working area, and numeral 7 denotes a nozzle station 7 which is provided near a component feed device 8A in the individual component-mounting working area of each mounting section and which accommodates therein a plurality of kinds of component suction nozzles 10 suited to a plurality of kinds of components 20 and, as required, replaces them with

nozzles 10 set on the mounting head 4. Numerals 8A, 8B denote component-parts-cassette type component feed devices which are provided at a shallow-side i.e. front-side end portion and a deep-side i.e. rear-side end portion, respectively, of the component-mounting working areas with respect to the operator, and which has a plurality of component feed cassettes 80 for accommodating the components 20, which are to be mounted onto the board 2, one by one into, for example, component-accommodation recessed portions of carrier tapes, and for feeding the components 20 one by one to component feed positions 89, numeral 8C denotes a tray type component feed device 8C which is provided near each component feed device 8B and which accommodates thereon tray components accommodated and held in a tray-like manner and being to be mounted onto the board 2, and numeral 9 denotes a two-dimensional or three-dimensional recognition camera which is provided in vicinity of each component feed device 8A and on a near side of the center of the component-mounting working area and which picks up the suction posture images of the components 20 sucked by the nozzles 10 of each mounting head 4.

The X-Y robot 5 is constituted as follows. Two Y-axis drive sections 6a, 6a of the X-Y robot 5 are fixedly set at front-and-rear end edges of component-mounting

working areas 200 of the individual mounting sections on a mounting apparatus base 16, and two X-axis drive sections 6b, 6c are extended over these two Y-axis drive sections 6a, 6a so as to be movable independently in the Y-axis direction and capable of avoiding collisions, where the mounting head 4 that moves within the front-side half mounting area of the component-mounting working area is disposed on the X-axis drive section 6b so as to be movable in the X-axis direction, while the mounting head 4 that moves within the rear-side half mounting area of the component-mounting working area is disposed on the X-axis drive section 6c. In each of the Y-axis drive sections 6a and the X-axis drive sections 6b, 6c, the drive section is constructed by X-Y robot motors 6y, 6x, ball screws that are driven forward and reverse by the motors 6y, 6x, and advanceable and retreatable members in which members to be moved are screwed with the ball screws and which are moved by the forward and reverse rotation of the ball screws based on the forward and reverse rotation drive of the motors 6y, 6x. The motors 6y, 6x are drive-controlled by an X-Y robot controller 1010 which is controlled by a later-described main controller 1000.

Further, as shown in Fig. 4, the main controller 1000 for controlling the board carriage-in and carriage-out, component holding, component recognition, component placing

operation and the like is also provided, and the component feed devices 8A, 8B, the component feed cassettes 80, the mounting heads 4, the recognition cameras 9, the board carrying-and-holding devices 3, the X-Y robots 5, a memory 910, the loader 1, the unloader 11, and the like are connected. In the memory 910 are stored NC data showing mounting programs as to, for example, which component are mounted, to which position and in which order they are mounted, arrangement programs as to, for example, which components are arranged on which component feed members, or arrangement information as to, for example, which components have been arranged on which component feed members, component libraries of component information as to the configuration, height, and the like of individual components, board information as to the configuration of individual boards, and other information as to the configuration of component suction nozzles and the board carriage position for the individual board carrying-and-holding devices 3, or the like.

As a basic operation of this component mounting apparatus, under the control of the main controller 1000, the front- and rear-side board carrying-and-holding devices 3 are driven to be moved toward the center so that the front- and rear-side board carrying-and-holding devices 3 are arrayed so as to be connected in line with the loader 1

and the unloader 11, and thereafter, the circuit board 2-2 is carried in from the loader 1 via the front-side board carrying-and-holding device 3 to the rear-side board carrying-and-holding device 3, and also the circuit board 2-1 is carried in from the loader 1 to the front-side board carrying-and-holding device 3, the individual circuit boards 2-1, 2-2 being held by the front- and rear-side board carrying-and-holding devices 3. After that, by the drive of the front- and rear-side board carrying-and-holding devices 3, 3, the boards are moved from the center-side board carrying-and-holding positions to specified placing positions near the component feed device 8A, respectively, as shown in Fig. 2.

Next, under the control of the main controller 1000, the each ten suction nozzles 10 are moved to, for example, suction preparatory positions upward of the individual component feed positions 89 for the ten component feed cassettes 80, respectively, by the mounting heads 4 based on the drive of the individual X-Y robots 5.

Next, the each ten suction nozzles 10 move down simultaneously from the suction preparatory positions toward the component feed positions 89 corresponding thereto, sucking and holding the ten components 20 located at the ten component feed positions 89, respectively, collectively and simultaneously or individually, and then

move again up to the suction preparatory positions.

Next, by the drive of the individual X-Y robots 5, the suction nozzles 10 move from the suction preparatory positions toward the recognition cameras 9, respectively, where while the each ten suction nozzles 10 move above their corresponding recognition cameras 9, the individual recognition cameras 9 recognize positions, postures, and configurations of the ten components 20.

Next, after the completion of recognition, based on the recognition results and under the control of the main controller 1000, the individual posture or position corrections of the ten components 20 are performed, as required, by performing the X- and Y-direction drive control of the mounting heads 4 (drive control of the X-Y robot motors 6y, 6x by the X-Y robot controller 1010) or θ-rotation drive control of the individual suction nozzles 10 (drive control of a θ-axis motor 25m by a servo driver 1002). Thereafter, the components 20 are set to specified mounting positions of the boards 2, respectively.

Meanwhile, the component suction devices 15, in which the nozzle turning device 25 and the nozzle up-and-down device 26 of each suction nozzle 10 are given in the same unit, each have the following constitution in detail.

First, as shown in Fig. 5A, the nozzle up-and-down device 26 is implemented by an up-and-down linear

motor 32 for moving up and down the nozzle turning device 25 along the axis of the suction nozzle 10. The nozzle turning device 25 is moved up and down by driving the up-and-down linear motor 32, by which the suction nozzle 10 is moved up and down along the axis of the suction nozzle 10.

More specifically, in the nozzle up-and-down device 26, as shown in Fig. 5A, a magnetic-circuit forming member 26a made of iron and magnets into a rectangular frame shape is fixed on a surface of a plate-shaped mechanism-forming member 26b of aluminum alloy or the like, and an up-and-down movable linear motor coil 26c within the magnetic-circuit forming member 26a is disposed so as to be movable in the up-and-down direction. The movable linear motor coil 26c is fixed and supported on the surface of the mechanism forming member 26b by being sandwiched between upper portions of a pair of support members 26s which are linearly guided in the up-and-down direction by linear guides 26g. The θ-axis motor 25m is fixed and supported at a lower portion of these paired support members 26s by being sandwiched from both sides thereby. In this arrangement, preferably, the center line of the θ-axis motor 25m is placed at the center of a thrust occurring to the linear motor 32 so that occurrence of unnecessary moment is prevented during up-and-down operations, by which swings due to the up-and-down operations are prevented.

Therefore, the magnetic-circuit forming member 26a and the linear motor coil 26c constitute the up-and-down linear motor 32, where by an electric current supplied to the linear motor coil 26c, the linear motor coil 26c is moved up and down while guided by the linear guides 26g within the magnetic-circuit forming member 26a, by which the θ-axis motor 25m coupled to the linear motor coil 26c with the pair of support members 26s is moved up and down integrally with the linear motor coil 26c. It is noted that reference numeral 26d denotes a cover of the up-and-down linear motor 32. Also, an up-and-down amount detection sensor for detecting an up-and-down amount of the linear motor coil 26c or the support members 26s is provided, so that a detected up-and-down amount is fed back to the later-described servo driver 1002 that controls the drive of the up-and-down linear motor 32.

The nozzle turning device 25, as shown in Fig. 5B, support the suction nozzle 10 by up-and-down bearings 25b so that the suction nozzle 10 is turnable, and an encoder 25e is provided at an upper end of the suction nozzle 10, where a current position of the suction nozzle 10 with respect to the origin position in its turning direction is detected by the encoder 25e, and a detected current position is fed back to the servo driver 1002 that controls the drive of the θ-axis motor 25m. A cylindrical magnet

25r is fixed on the central-part outer periphery of the suction nozzle 10, and a stator 25s is fixed to a casing 25c of the nozzle turning device 25, where the cylindrical magnet 25r and the stator 25s constitute the θ-axis motor 25m. A suction discharge chamber 25d sandwiched by packings 25a is formed at an upper portion of the suction nozzle 10, and an upper-end opening 10c of the suction nozzle 10 is kept communicating with the suction discharge chamber 25d at all times so as to be coupled to a air feed/discharge passage 25p via the suction discharge chamber 25d. By the drive of an air feed/discharge device 50 which is connected to the air feed/discharge passage 25p by being coupled to the air feed/discharge passage 25p via the suction discharge chamber 25d and which is composed of a vacuum pump, a compressed-air feed device, and the like, suction and discharge (blow) operations of the suction nozzle 10 can be performed, when necessary, regardless of the turning position of the suction nozzle 10 by, for example, opening and closing operations and suction and discharge (blow) switching operations of valves 90 shown in Fig. 16.

Next, a variety of examples of operations of the ten component suction devices 15 are explained. First described is a case where ten nozzles 10 move down independently, one by one, to perform component suction.

In this case, typically, a first component suction device 15-1 and a second component suction device 15-2 are described with reference to Fig. 3. After component feed from the component feed device 8A or 8B by the suction nozzle 10-1 of the first component suction device 15-1 and component suction-and-holding operation by the suction nozzle 10-1 are performed, the suction nozzle 10-1 is subjected to a component turning operation that the suction nozzle 10-1 is turned about the axis, for example, a θ-axis extending along the up-and-down direction by the θ-axis motor 25m so as to be turned to its placing posture angle. Meanwhile, after component feed from the component feed device 8A or 8B by the suction nozzle 10-2 of the second component suction device 15-2 and component suction-and-holding operation by the suction nozzle 10-2 are performed, the suction nozzle 10-2 is subjected to a turning operation that the suction nozzle 10-2 is turned to its placing posture angle by the θ-axis motor 25m, where the component suction-and-holding operation by the suction nozzle 10-2 of the second component suction device 15-2 is started when the component turning operation by the suction nozzle 10-1 of the first component suction device 15-1 is started. By doing so, while a suction operation by one suction nozzle 10 is going on, another suction nozzle 10 is enabled to perform the turning operation to the placing

posture angle, so that the mounting time can be reduced greatly, as compared with cases where the turning operation for all the components to their placing posture angles is performed after the suction operation for all the components is done.

As another example, component suction, recognition, and placing operations of ten components 20 may also be done simultaneously by ten nozzles 10 by one operation. This is described in detail below with reference to Figs. 6 and 7.

In Fig. 6, "M" denotes movement, "S" scanning operation, "D" moving-down operation, "U" moving-up operation, "C" correction operation, "R" origin, "CS" component suction operation, "CSOFF" release of component suction, "B" blow operation, "CP" recognition processing operation.

As a reference, operations in the prior art are described first.

In the prior art, as shown in Fig. 22, Fig. 8 and Fig. 9, the mounting head 307 moves in the X-axis direction and/or the Y-axis direction to above specified component feed positions of ten component feed cassettes (step S41 in Fig. 9), and the ten nozzles 304 are moved down at a time from their move-enabled height positions, which are their initial positions, to their component-suction-enabled

height positions by the drive of the up-and-down motor 312, so that ten components located at the component feed positions of the ten component feed cassettes are sucked and held by the ten nozzles 304 (step S42 in Fig. 9). Thereafter, the ten nozzles 304 are moved at a time up from their component-suction-enabled height positions to their move-enabled height positions by the drive of the up-and-down motor 312, i.e., returned to the heightwise origin position (step S43 in Fig. 9).

In Fig. 8, "M" denotes movement, "S" scanning operation, "D" moving-down operation, "U" moving-up operation, "C" correction operation, "R" origin, "CS" component suction operation, "CSOFF" release of component suction, "B" blow operation, "CP" recognition processing operation, "SL" selection.

Next, the head moves in the X-axis direction to the recognition position (step S44 in Fig. 9). After the ten nozzles 304 are moved down at a time from their move-enabled height positions to their component-recognition-enabled height positions by the drive of the up-and-down motor 312 (step S45 in Fig. 9), moving linearly in one direction above the recognition camera to thereby accomplish the recognition operation of the ten components sucked and held by the ten nozzles 304 (step S46 in Fig. 9). Thereafter, by the drive of the up-and-down motor 312, the

ten nozzles 304 are moved up at a time from their component-recognition-enabled height positions to their move-enabled height positions, i.e., returned to the heightwise origin position (step S47 in Fig. 9).

Next, the mounting head 307 is moved to, for example, a component mounting position for a component held by the first nozzle 304 (step S48 in Fig. 9). Then, based on the recognition result, the first nozzle 304 is turned about its axis from its turning-direction origin position to a position corresponding to a total of placing posture angle and correction angle by the drive of the turn-actuating motor 311, thereby correcting the posture angle of the held component (step S49 in Fig. 9). By the drive of the up-and-down motor 312, the first nozzle 304 alone is selected by a cylinder 310 and moved down from its move-enabled height position to its component-placing-enabled height position, by which the component held by the first nozzle 304 is placed onto the board (step S50 in Fig. 9). After that, by the drive of the up-and-down motor 312, the first nozzle 304 alone is moved up from its component-placing-enabled height position to its move-enabled height position. Then, by the drive of the turn-actuating motor 311, the first nozzle 304 is turned about its axis to the turning-direction origin position.

Subsequently, if component placing has not yet

been completed for all the components held by the mounting head 307 (step S51 in Fig. 9), the program goes to the next mounting operation.

In the next mounting operation, the mounting head 307 is moved to, for example, a component mounting position for a component held by the second nozzle 304 (step S48 in Fig. 9). Then, based on the recognition result, the second nozzle 304 is turned about its axis from its turning-direction origin position to a position corresponding to a total of placing posture angle and correction angle by the drive of the turn-actuating motor 311, by which the held component is corrected in posture angle (step S49 in Fig. 9). By the drive of the up-and-down motor 312, the second nozzle 304 alone is selected by a cylinder 310 and moved down from its move-enabled height position to its component-placing-enabled height position, by which the component held by the second nozzle 304 is mounted onto the board (step S50 in Fig. 9). After that, by the drive of the up-and-down motor 312, the second nozzle 304 alone is moved up from its component-placing-enabled height position to its move-enabled height position. Then, by the drive of the turn-actuating motor 311, the second nozzle 304 is turned about its axis to the turning-direction origin position.

From this on, similarly, the placing of the

components held by the third to tenth nozzles 304 onto the board is performed one after another (steps S48 to S51 in Fig. 9), the mounting head 307 moves to above the specified component feed positions of the ten component feed cassettes for the next component suction operation in the X-axis direction and/or Y-axis direction (step S41 in Fig. 9). From this on, the component suction, move to the recognition positions, component recognition, move to the component placing positions, correction of component posture angle, and component placing operation of steps S41 to S51 of Fig. 9 are iterated.

That is, in the prior art, since one nozzle 304 alone for next placing a component is turned after component recognition and subjected to position correction and thereafter the placing operation onto the board is performed, it has inevitably been involved to do two operations for each nozzle 304 that is over the recognition (step S46 in Fig. 9), i.e., turning-position correction (step S49 in Fig. 9) and component placing (step S50 in Fig. 9).

In contrast to this, in the first embodiment, as shown in Figs. 13 and 7, the mounting head 4 is moved by the drive of the X-Y robot motors 6y, 6x of the X-Y robots 5 in the X-axis direction and/or the Y-axis direction to above the specified component feed positions 89 of the ten

component feed cassettes 80 (step S1 in Fig. 7), and the ten nozzles 10 are moved down by the drive of the up-and-down linear motor 32 of the nozzle up-and-down device 26 at a time from their move-enabled height positions, which are their initial positions, to their component-suction-enabled height positions so that the ten components 20 located at the component feed positions of the ten component feed cassettes are sucked and held at a time by the ten nozzles 10 (step S2 in Fig. 7). Thereafter, by the drive of the nozzle up-and-down device 26, the ten nozzles 10 are moved up at a time from their component-suction-enabled height positions to their move-enabled height positions, i.e., returned to the heightwise origin positions (step S3 in Fig. 7).

Next, while the mounting head 4 is moved by the drive of the X-Y robots 5 to the recognition position in the X-axis direction (step S4 in Fig. 7), the nozzles 10 are turned about their respective axes from the turning-direction origin positions to their placing posture angles by the drive of the nozzle turning device 25, by which the components 20 held by those nozzles 10 are put into the placing posture (step S5 in Fig. 7).

Next, by the drive of the nozzle up-and-down device 26, the ten nozzles 10 are moved down at a time from their move-enabled height positions to their component-

recognition-enabled height positions (step S6 in Fig. 7), and then moved linearly above the recognition camera 9, by which the recognition operation of the ten components 20 sucked and held by the ten nozzles 10 is performed (step S7 in Fig. 7). Thereafter, by the drive of the nozzle up-and-down device 26, the ten nozzles 10 are moved up at a time from their component-recognition-enabled height positions to their move-enabled height positions, i.e., returned to the heightwise origin position (step S8 in Fig. 7).

Next, while the mounting heads 4 is moved by the drive of the X-Y robot 5 to, for example, a component placing position for a component 20 held by the first nozzle 10 (step S9 in Fig. 7), the individual nozzles 10 are turned concurrently about their axes from the placing posture angle to the correction positions based on the recognition result, by which the components 20 held by the individual nozzles 10 are corrected in posture angle (step S10 in Fig. 7). Therefore, at the time when the mounting head 4 is placed at the component placing position for the component 20 held by the first nozzle 10, the posture angle correction for all the nozzles 10 has been completed. In this operation, although all the nozzles 10 may be subjected to the posture angle correction, more appropriately, only nozzle(s) 10 just before the placing are subjected to the correction when a higher-precision

placing is desired.

Next, by the drive of the nozzle up-and-down device 26, the first nozzle 10 alone is moved down from its move-enabled height position to its component-placing-enabled height position, by which the component held by the first nozzle 10 is placed onto the board 2 (step S11 in Fig. 7). After that, by the drive of the nozzle up-and-down device 26, the first nozzle 10 alone is moved up from its component-placing-enabled height position to its move-enabled height position. Then, by the drive of the θ-axis motor 25m of the nozzle turning device 25, the first nozzle 10 is turned about its axis to the turning-direction origin position.

Subsequently, if component placing has not yet been completed for all the components 20 held by the mounting head 4 (step S12 in Fig. 7), the program goes to the next mounting operation.

In the next mounting operation, while the mounting head 4 is moved to, for example, a component placing position for a component 20 held by the second nozzle 10 by the drive of the X-Y robot 5 (step S9 in Fig. 7), the second nozzle 10 is turned concurrently about its axis from the placing posture angle to the correction position based on the recognition result by the drive of the nozzle turning device 25, by which the component 20

held by the second nozzle 10 is corrected in posture angle (step S10 in Fig. 7). Only the second nozzle 10 is moved down from its move-enabled height position to its component-placing-enabled height position by the drive of to the nozzle up-and-down device 26, by which the component 20 held by the second nozzle 10 is placed onto the board 2 (step S11 in Fig. 7). Thereafter, by the drive of the nozzle up-and-down device 26, the second nozzle 10 alone is moved up from its component-placing-enabled height position to its move-enabled height position. Then, by the drive of the nozzle turning device 25, the second nozzle 10 is turned about its axis to the turning-direction origin position.

From this on, similarly, the placing of the components 20 held by the third to tenth nozzles 10 onto the board 2 is performed one after another (step S12 in Fig. 7), the mounting head 4 moves to above the specified component feed positions of the ten component feed cassettes 80 for the next component suction operation in the X-axis direction and/or Y-axis direction by the drive of the X-Y robot 5 (step S1 in Fig. 7). From this on, the correction of component posture angle and the component placing operation are iterated simultaneously with the component suction, move to the recognition positions, component recognition, and move to the component placing

positions of steps S2 to S12 of Fig. 7.

That is, by performing the placing-posture-angle correction operation simultaneously with the move operation to the component placing position, the time for performing the placing-posture-angle correction operation alone can be eliminated, so that the mounting time can be reduced as a whole.

It is noted that also in the first embodiment, as in the prior art, each nozzle 10 once exerts a blow just after the placing of the component 20 onto the board 2 so as to ensure that the component 20 goes away from the nozzle 10.

It is also possible that after the components 20 are sucked and held from the component feed device 8A or 8B and held by the nozzles 10 of the plurality of component suction devices 15, respectively, and before the component recognition with the recognition camera 9 is started, the individual nozzles 10 are moved up and down by driving the nozzle up-and-down device 26 under the control of the main controller 1000, a head controller 1001, and the servo drivers 1002 based on component-height information which has been stored in the memory 910 and which concerns the components sucked and held by the individual nozzles 10, so that the bottom faces of the components 20 are adjusted to a constant height of H1 as shown in Fig. 10 or that the

bottom faces of the components 20 are restricted so as to fall within a constant height range, i.e., the depth of field of the recognition camera 9. More specifically, as shown in Fig. 11A, data as to operations, a component database, component-feed-cassette arrangement data, or other information are preliminarily stored in the memory 910. In the component database, as shown in Fig. 11B are stored sizes (width w, thickness t, depth D) of the individual components and information concerning electrodes of the components (information as to the number of poles, electrode width and other sizes, positions, etc.). As shown in Fig. 11C, the component-feed-cassette arrangement data include serial component-feed-cassette numbers, link information with component types corresponding to the cassette numbers, link information between component types and model numbers, etc. The terms, component type, herein refer to, for example, 1005R (i.e., a resistor having a component size of 1.0 mm × 0.5 mm), 1608R (i.e., a resistor having a component size of 1.6 mm × 0.8 mm), and the like. Therefore, for instance, as shown in Fig. 12, the main controller 1000 first acquires suction component information for all the nozzles 10 from the memory 910 (step S61).

Next, the main controller 1000 determines a cassette numbers from the suction component information by

referring to the link information of the memory 910 (step S62 in Fig. 7).

Next, the main controller 1000 determines a cassette coordinate positions in the component mounting apparatus (equipment) from the cassette numbers by looking up to the link information of the memory 910 (step S63).

Next, the mounting heads 4 is moved to the suction positions by driving the X-Y robot 5 under the control of the main controller 1000, the head controller 1001, and the servo drivers 1002, and suction heights are calculated by the main controller 1000 based on the information stored in the memory 910 (e.g., information as to the thicknesses of the components to be sucked to the nozzle, information as to the component suction positions of the cassettes) (step S64).

Next, based on the calculated suction height, the nozzle up-and-down device 26 is driven under the control of the main controller 1000, the head controller 1001, and the servo drivers 1002, by which each nozzle 10 is moved down to the calculated suction height (step S65).

Next, the valves 90 are driven under the control of the main controller 1000, the head controller 1001 and the servo drivers 1002, by which the component suction operation is performed (step S66).

Next, sucked-component information for every

nozzle is stored into the memory 910 by the main controller 1000 (step S67).

Next, the nozzle up-and-down device 26 is driven under the control of the main controller 1000, the head controller 1001, and the servo drivers 1002, by which each nozzle 10 is moved up to the heightwise origin position (step S68).

Next, the X-Y robot 5 is driven under the control of the main controller 1000, the head controller 1001, and the servo drivers 1002, by which the mounting head 4 is moved to the recognition position (step S69).

Next, by the main controller 1000, the recognition height of each nozzle 10 for adjusting the bottom faces of the individual components 20 uniformly to the constant height H1 is calculated based on the information in the memory 910 (e.g., information as to the thicknesses of the components sucked by the nozzles) (step S70).

Next, based on the calculated recognition height of each nozzle 10, the nozzle up-and-down device 26 is driven under the control of the main controller 1000, the head controller 1001, and the servo drivers 1002, by which each nozzle 10 is moved down from the heightwise origin position to the recognition height (step S71). In this operation, the bottom faces of the components 20 sucked and

held by the individual nozzles 10 may be adjusted uniformly to the constant height H1 as shown in Fig. 10.

Next, the X-Y robot 5 is driven under the control of the main controller 1000, the head controller 1001, and the servo drivers 1002, by which the mounting head 4 is made to pass through above the recognition camera 9, allowing the recognition operation to be done (step S72).

Next, the nozzle up-and-down device 26 is driven under the control of the main controller 1000, the head controller 1001, and the servo drivers 1002, by which each nozzle 10 is moved up to the heightwise origin position (step S73).

Next, the X-Y robot 5 is driven under the control of the main controller 1000, the head controller 1001, and the servo drivers 1002 so as to be moved to the mounting position (step S74).

Next, by the main controller 1000, a mounting down height is calculated based on the information in the memory 910 (e.g., information as to the thickness of the component to be sucked to the nozzle, information as to the board thickness, etc.) (step S75).

Next, based on the calculated mounting down height, the nozzle up-and-down device 26 is driven under the control of the main controller 1000, the head controller 1001, and the servo drivers 1002, by which

nozzle to do mounting is moved down to the mounting down height (step S76).

Next, the nozzle up-and-down device 26 is driven under the control of the main controller 1000, the head controller 1001, and the servo drivers 1002, by which the nozzle 10 to do mounting is moved down to the mounting down height. This state is maintained for a moment, by which the component mounting operation onto the board 2 is accomplished (step S77).

Next, the nozzle up-and-down device 26 is driven under the control of the main controller 1000, the head controller 1001, and the servo drivers 1002, by which the nozzle 10 that has done mounting operation is moved up to the heightwise origin position (step S78).

Next, it is checked by the head controller 1001 and the servo drivers 1002 whether or not the component mounting operation has been done for all the nozzles 10 of the mounting head 4. In order that nozzles 10 that have not yet done, if any, are put into the operation, the program returns to step S74 (step S79). If the component mounting operation has been completed for all the nozzles 10, the program returns to step S61.

With this method as described above, since recognition surfaces, e.g., bottom surfaces of all the components can be set to within the depth of field of the

recognition camera 9 at the process of recognition, even those components which thicknesses largely differ from one another can be treated collectively for recognition operation. As a result, such disadvantages as incapability of recognition due to the recognition surfaces not falling within the depth of field can be eliminated without fail.

Now, communications between the main controller 1000 of the component-mounting-apparatus main body and each mounting head 4, and control operations between the main controller 1000 and each servo driver 1002 for controlling the head controller 1001, the θ-axis motor 25m, and the up-and-down linear motor 32 in each mounting head 4, as well as the constitution therefor, are described below.

In this first embodiment, with a view to reducing any increase in cable connections between the component-mounting-apparatus main body and the mounting heads 4 due to any increase of the number of actuators, as well as to implementing the modularization of the mounting heads 4, this apparatus adopts a method in which the drive control section for controlling up-and-down and turning operations of the individual nozzles of the mounting head, which have been conventionally controlled by an NC board 901 mounted on a control unit of the component-mounting-apparatus main body, is implemented by the head controller 1001 and the servo drivers 1002, which are integrated into one unit and

mounted on the mounting head 4 side, where communications between the head controller 1001 and the main controller 1000 are done in a serial manner. In order to implement such a system, there is a need for reducing the amount of communications between the main controller 1000 and the head controller 1001 and, therefore, a command system by asynchronous communications is adopted. Also, communications between the head controller 1001 and each servo driver 1002 are done by transmission in synchronous communications, while one-to-multi broadcasting is enabled from the head controller 1001 to the individual servo drivers 1002. Further, communications from the individual servo drivers 1002 to the head controller 1001 are done in a one-to-one system in which the communication path is switched in time division with interrupt notifications given. By implementing communications in such a full duplex communication system, issues with an increase in communication traffic due to an increase in the number of actuators, i.e., a multiplication of axes can be solved.

The above-described system is explained below in detail on a case of controlling the θ-axis motor 25m, which is a servomotor for the nozzle turning device 25 of the component suction device 15, and the up-and-down linear motor 32 for the nozzle up-and-down device 26 in the component mounting apparatus.

As shown in Figs. 13, 14 and 16, the main controller 1000, i.e. controller for controlling the machine (MMC), is mounted on the component-mounting-apparatus main body, while the head controller 1001 and the servo drivers 1002, as well as the members or devices to be driven and controlled such as the θ-axis motor 25m or the up-and-down linear motor 32 are mounted on the mounting heads 4.

The main controller 1000 has a function of setting operating characteristics, for example, it sets travel distance, acceleration, maximum speed, and speed command waveform pattern of the members or devices to be driven and controlled.

The main controller 1000 and the head controller 1001 are connected to each other in such a serial connection as to be both switchable between transmission side and reception side, as required, where one-to-one communications are performed asynchronously.

In order to reduce the communication traffic in this case, first, it is arranged that not only communications by specifying the axes of the nozzles 10 individually but also broadcasting for all the axes to the nozzles 10 are possible. Also, in order that the values of operating speed and acceleration for each nozzle 10 can be selected from, for example, eight kinds of specified values,

respectively, it is designed that, for example, eight kinds of specified values of speed and acceleration for the individual nozzles 10 are preliminarily transmitted to the head controller 1001 so as to be stored as a table in a memory 1005 connected to the head controller 1001. As a result of this, only transmitting, for example, one specified value selected out of the eight kinds, allows the each nozzle 10 to operate at a desired speed or acceleration. It is further arranged that with provisions of commands for instructing suction operation by the nozzles 10 as well as commands for instructing placing operation by the nozzles 10, a sequence of suction and placing operation can be performed only by transmitting travel amount and bottom dead-point time for each operation. More specifically, for example, with information as to suction operation by the nozzles 10 and placing operation by the nozzles 10 preliminarily stored in the memory 1005 connected to the head controller 1001, when a suction-operation instruction command or a placing-operation instruction command is transmitted from the main controller 1000 to the head controller 1001, information as to a relevant operation is read from the memory 1005, and based on the information as to travel amount and dead-point time, the servo driver 1002 is made to perform the relevant operation. Therefore, in the case where component suction

is performed by, for example, ten nozzles 10, it is only required to transmit a command for instructing the suction operation by the nozzles 10 to all the ten nozzles 10, as well as a signal containing a down amount and a dead-point time for the suction by each nozzle 10, and specified values of operating speed and acceleration for up-and-down move of each nozzle 10, from the main controller 1000 to the head controller 1001. Also, in the case where component placing is performed by, for example, the first nozzle 10-1 out of the ten nozzles 10, it is only required to transmit a command for instructing the placing operation by the first suction nozzle 10-1 to the first suction nozzle 10-1, as well as a signal containing a down amount and a dead-point time for the placing by the first suction nozzle 10-1, and specified values of operating speed and acceleration for up-and-down move of the first suction nozzle 10-1, from the main controller 1000 to the head controller 1001.

The head controller 1001 has a function of conversion into instructions in unit time, where, for example, a travel amount for the unit time of synchronous communications is calculated based on set values from the upper-order main controller 1000, and then transmitted to the servo drivers 1002.

The head controller 1001 and the servo drivers

1002 are connected to each other in serial connection, so that one-to-multi communications are performed in synchronous communications.

With the full duplex communication system used for improvement in communication responsivity of communications in this case, it is enabled to simultaneously perform communication from the head controller 1001 to each servo driver 1002 and communication from each servo driver 1002 to the head controller 1001. Further, the communication from the head controller 1001 to each servo driver 1002 is a one-to-multi communication in which communications from the head controller 1001 are simultaneously transmitted to all the servo drivers 1002. That is, the same data, commands, or the like are transmitted to all the servo drivers 1002. Therefore, all the servo drivers 1002 have addresses different from one another, and only those correspondent in the addresses and an order of the sent data, commands, or the like are taken into the individual servo drivers 1002. This allows the communication time to remain almost unchanged even if the number of the servo drivers 1002 is increased. In contrast to this, in the prior art, since data or instruction information is transmitted to the servo drivers 1002 in time division, there has been an issue that increases in the number of servo drivers 1002 would cause the

communication time to be prolonged proportionally. Such an issue is solved by the concurrent broadcasting of information and the check and selection according to addresses. Further, for communications from the servo drivers 1002 to the head controller 1001, the synchronization cycle is equally divided into five, and data or the like is transmitted at the individual divided cycles sequentially from address 1.

Since the communication responsivity can be improved with the above-described constitution, the communication time remains almost unchanged even if the number of the servo drivers 1002 is increased. In contrast to this, in the prior art, since data or instruction information is transmitted to the individual servo drivers 1002 in time division, there has been an issue that increases in the number of servo drivers 1002 would cause the communication time to be prolonged proportionally. Such an issue is solved by the concurrent broadcasting of information and the check and selection according to addresses.

Each of the servo drivers 1002 has a function of controlling the position of a corresponding servomotor (θ-axis motor 25m) or the up-and-down linear motor 32. For example, the servo driver 1002 calculates a difference between a given command and a feedback amount derived from

an encoder of the servomotor or an up-and-down amount detection sensor of the up-and-down linear motor 32, and controls the torque of the servomotor or the up-and-down amount of the up-and-down linear motor 32 to obtain coincidence with a targeted position.

The servo drivers 1002 and the members or devices to be driven and controlled such as the θ-axis motor 25m or the up-and-down linear motor 32 are connected to each other with various types of electrical wires.

As shown above, in the first embodiment, the main controller 1000 is mounted on the component-mounting-apparatus main body, while the head controller 1001, the servo drivers 1002, and the members or devices to be driven and controlled such as the θ-axis motor 25m or the up-and-down linear motor 32 are mounted on the mounting head 4.

In contrast to this, in the prior art, as shown in Fig. 15, a main controller 900, an NC board 901, and servo drivers 902 for individual servomotors 903 are mounted on the control unit of the component-mounting-apparatus main body, while the servomotors 903 only are mounted on the mounting head 307 of Fig. 22. The main controller 900 has a function of setting operating characteristics, and, for example, sets travel distance, acceleration, maximum speed, and speed command waveform pattern of the members or devices to be driven and

controlled. The main controller 900 and the NC board 901 are connected to each other in a bus connection, where one-to-one communications are performed asynchronously. The NC board 901 has a function of conversion into instructions in unit time, where, for example, a travel amount for the unit time of synchronous communications is calculated based on set values from the upper-order main controller 900, and then transmitted to the servo drivers 902. The NC board 901 and the servo drivers 902 are connected to each other in serial connection, so that one-to-multi communications are performed in synchronous communications. Each of the servo drivers 902 has a function of controlling the position of a corresponding servomotor 903 (turn-actuating motor 311 or up-and-down motor 312 in Fig. 22). For example, the servo driver 902 calculates a difference between a given command and a feedback amount derived from an encoder of the servomotor 903, and controls the torque of the servomotor 903 to obtain coincidence with a targeted position. With such a prior-art constitution, implementing up-and-down operations and turn-correcting operations of the individual nozzles 10 independently of one another as in the first embodiment would involve mounting a nozzle turning device 25 and a nozzle up-and-down device 26 on each nozzle 10. This would result in an increase in the number of actuators, for example, compared with the

constitution of the prior-art mounting head 307 of Fig. 22, which in turn would result in an increase in the number of servo drivers 902 that control the actuators. In the prior art, the servo drivers 902 would be mounted on the fixed side, i.e., on the component-mounting-apparatus main body, while the actuators (servomotors 903) only would be mounted on the mounting head 307. With a similar constitution, in the prior art, the wiring lines for connecting the servo drivers 902 and the actuators, for ten nozzles as an example, would result in a total of two wiring lines in conjunction with the servo drivers 902 since two actuators consisting of one up-and-down motor 312 and one turn-actuating motor 311 are involved, or in a total of three wiring lines in conjunction with the servo drivers 902 since three actuators consisting of one up-and-down motor 312 and two turn-actuating motors (a turn-actuating motor for odd-numbered nozzles and a turn-actuating motor for even-numbered nozzles) are involved. In contrast to this, since a total of twenty actuators consisting of ten turn-actuating motors and ten up-and-down motors for ten nozzles are involved, a total of twenty wiring lines in conjunction with the servo drivers 902 result. These are seven to ten times as large as the number of wiring lines of the prior art, making it impractical to do wiring. Also, the servo drivers would increase in number seven to ten times larger,

causing their installation area to increase, making it difficult to accommodate those servo drivers into the component mounting apparatus. To solve these and other issues, the first embodiment is so arranged that the servo drivers 1002 are downsized, reduced in weight, and mounted on the mounting head 4.

More specifically, first, two actuators are controlled by one servo driver 1002. In more detail, in order to control the two motors of the θ-axis motor 25m and the up-and-down linear motor 32 with one servo driver 1002, a high-speed CPU 1002a is mounted as a controller dedicated to the servo driver 1002 so that servo operations for the two-axis actuators can be performed with the one CPU 1002a, and that the mounting area of the controller board for providing the servo driver 1002 can be reduced to enable the downsizing of the servo driver 1002. Further, on the head controller 1001 side, a head controller 1001 specialized in the function of head control is mounted on the mounting head 4 in order to implement one-to-one communications between the main controller 1000 and the head controller 1001 in this first embodiment, other than one-to-multi communications between the NC board 901 and the servo drivers 902 in the prior art. Further, the main controller 1000 and the head controller 1001 are connected in serial communication, allowing power supply cable and

communication cable to be each one in number. In addition, it is devised to implement multi-axis control in serial communication by establishing a communication protocol, i.e., by implementing a protocol for reducing the communication traffic.

Now, as an example of the signal to be transmitted from the main controller 1000 to the head controller 1001, here is discussed a case where the mounting head 4 moves up and down only selected nozzles 10 out of the ten nozzles 10 in the component feed position(s) to perform the component suction. While the mounting head 4 is moving toward the component feed position(s), signal(s) containing drive-amount information for servo driver(s) 1002 to be selected out of the servo drivers 1002 that control the θ-axis motors 25m of ten nozzle turning devices 25 and the up-and-down linear motors 32 of ten nozzle up-and-down devices 26 for the ten nozzles 10 are transmitted from the main controller 1000 to the head controller 1001.

The drive-amount information, as an example, contains address information on the selected servo driver(s) 1002 that should receive drive-amount information, travel or up-and-down distance design information corresponding to down amount(s) predetermined at the design stage of the nozzle(s) driven by servo driver(s) 1002 at

the address(es), travel or up-and-down distance correction information which is correction information for determining the actual preferable down amount(s) for the nozzle(s) 10 from the travel or up-and-down distance design information, and check information for checking that the signal of drive-amount information has been correctly received. Therefore, the head controller 1001, which has received the drive-amount information signal from the main controller 1000, first checks that the drive-amount information signal has been correctly received, and then transmits a check result, as a check result signal, to the main controller 1000. If the signal containing drive-amount information has not been received correctly by the head controller 1001, the main controller 1000 transmits the signal containing drive-amount information once again to the head controller 1001, waiting for a check result signal from the head controller 1001. If the signal containing drive-amount information has been received correctly by the head controller 1001, the head controller 1001 calculates actual travel or up-and-down distance information from the travel or up-and-down distance design information and the travel or up-and-down distance correction information, and making the information temporarily stored in the memory 1005 as required.

On the other hand, after the main controller 1000

has received an arrival signal indicating that the mounting head 4 has arrived at the component feed position, a signal containing an operation start signal is transmitted from the main controller 1000 to the head controller 1001. The operation start information, as an example, contains address information on the servo driver(s) 1002 to be started operating, and down-move start signal(s) of the nozzle(s) to be driven by the servo driver(s) 1002 at the address(es).

Once the signal containing an operation start signal has been received by the head controller 1001 as shown above, the head controller 1001 simultaneously transmit to all the servo drivers 1002 the motor-dedicated drive-amount signal containing actual travel or up-and-down distance information calculated for all the servo drivers 1002 and address information on the servo driver(s) 1002 that should receive drive-amount information. By transmission from the head controller 1001, only the servo driver(s) 1002 having the address(es) that should receive the drive-amount information receive the actual travel or up-and-down distance information, and immediately drives and controls the up-and-down linear motor(s) 32 based on this actual travel or up-and-down distance information to lower the nozzle(s) 10 to make the nozzle(s) 10 carry out the component suction-and-holding operation.

In addition, in the case where the ten nozzles 10 are lowered at a time to perform suction operation, respective pieces of the drive-amount information and the simultaneous operation start signal for each of all the servo drivers 1002 are transmitted from the main controller 1000 to the head controller 1001, and the signals containing actual travel or up-and-down distance information for each of the servo drivers 1002 are transmitted simultaneously from the head controller 1001 to all the servo drivers 1002 by which the servo drivers 1002 are individually controlled so that the nozzles 10 are simultaneously lowered.

In operations (e.g., recognition operation, placing operation or the like) other than the above-described suction operation, similarly, before the members or devices which are to operate in the operations come to their operating positions, drive-amount information as to the servo drivers 1002 that should drive and control the members or devices to operate is transmitted from the main controller 1000 to the head controller 1001, and the head controller 1001 calculates actual travel or up-and-down distance information, where an operation start signal is waited. When the members or devices to operate are located at their operating positions or have approached to those operating positions, the operation start signal is

transmitted from the main controller 1000 to the head controller 1001, and the head controller 1001 transmits the address(es) of the servo driver(s) 1002 to be driven and controlled as well as the actual travel or up-and-down distance information to all the servo drivers 1002, by which the servo driver(s) 1002 that should do the drive control are put into operation.

Thus, by dividing the signal for communications into a signal containing drive-amount information and a signal containing operation start information and by transmitting or receiving the signals at proper timings, respectively, the amount of signal transmission can be reduced to approximately one third, compared with cases in which the two signals are simultaneously transmitted.

Meanwhile, information to be transmitted in communications from the head controller 1001 to the main controller 1000 includes address information on the individual servo drivers 1002, current-position information as to current positions of the members or devices driven and controlled by the servo drivers 1002, and state information on the members or devices (e.g., valve on/off information, error information as to halts due to overloads or the like, electric current information, etc.), in addition to the above-described check result signal.

In addition, referring to Fig. 16, reference

numeral 1002a denotes a CPU 1002a dedicated for servo drivers, 90 denotes a valve that turns on/off the suction or discharge (blow) operation of the nozzle 10 which are driven and controlled by the servo-driver dedicated CPU 1002a, 91 denotes an interface of signals which derive from the position detector of the up-and-down linear motor 32 and which are inputted to the servo-driver dedicated CPU 1002a, and 92 denotes an interface of signals which derive from the encoder of the θ-axis motor 25m and which are inputted to the servo-driver dedicated CPU 1002a. Numeral 93 denotes an amplifier for amplifying a drive-control current from the servo-driver dedicated CPU 1002a to the up-and-down linear motor 32, 94 denotes an amplifier for amplifying a drive-control current from the servo-driver dedicated CPU 1002a to the θ-axis motor 25m, 95 denotes a serial interface, 96 denotes an interrupt interface, 97 denotes a CPU of the head controller 1001, 97 denotes a CPU of the head controller 1001, 97 denotes a power supply section, and 98 denotes a DCDC converter of the power supply section 97.

According to the first embodiment, the nozzle 10 that has sucked up the component 20 can be turned to a desired angle at any arbitrary timing by the nozzle turning device 25, and moreover the nozzle 10 can be moved up and down to a desired height at any arbitrary timing by the

nozzle up-and-down device 26. Therefore, in the mounting head 4 equipped with a plurality of component suction devices 15, all the nozzles 10 can be turned to their respective desired angles at the same timing by driving and controlling all the nozzle turning devices 25 at the same timing. Accordingly, after the component suction and before its recognition, the components 20 can be turned in their respective nozzles 10 to their placing posture angles by the drive of the individual nozzle turning devices 25, especially even during the move from the component suction position to the recognition position. As a result of this, the need for largely turning the nozzles to their placing posture angles just before placing is eliminated, so that the turning operation time can be reduced, and that the mounting cycle time as a whole can be reduced.

Also, before placing, the nozzles 10 can be turned to their respective correction angles at a time by the drive of the individual nozzle turning devices 25, so that the need for turning the nozzles individual to their correction angles just before placing is eliminated, and that the mounting cycle time can be reduced.

Also, since the nozzle turning devices 25 and the nozzle up-and-down devices 26 can be driven and controlled individually and independently, it is possible that during the component suction operation or component placing

operation performed by one nozzle 10 that has, for example, moved down, the other nozzles 10 perform the turning operation of the sucked and held components. It is therefore possible to concurrently perform different operations by a plurality of nozzles 10, so that the mounting cycle time can be shortened.

With the nozzle up-and-down device 26 arranged below the nozzle turning device 25, turning drive of the nozzle turning device 25 would cause the nozzle up-and-down device 26 to turn along with the nozzle 10, in which case the wiring lines for the nozzle up-and-down device 26 and the like would be complicated in structure. However, in the first embodiment, since the nozzle up-and-down device 26 is located above the nozzle turning device 25, turning drive of the nozzle turning device 25 does not cause the nozzle up-and-down device 26 to turn along with the nozzle 10, in which case such a disadvantage as described above does not occur.

In more detail, superior working effects as shown below can be produced, in comparison with the issues of the prior art.

First, the mounting head 307 as shown in Fig. 22 has had the following issues so far.

① Load factor for the motor 312 or 311 is high; because a plurality of nozzles 304 are operated by one motor 312 or

311, operation frequency of the motor 312 or 311 is high and a high-power motor is necessitated.

② Improvement in throughput is difficult; improving the operating speed and acceleration of the nozzles 304 to thereby improve the mounting cycle time (throughput) in view of the issue of ① would involve increase in motor size (increase in power), which in turn would cause the mounting head 307 to increase in dimensions and mass, with the results of increased loads on other driver devices such as the X-Y robot that operates the mounting head 307, as well as an impossibility of providing a multi-head structure.

③ Placing precision is poor; that is, the precision becomes poor when large correction angle operations are required depending on the orientation of components (e.g., when the placing posture angle is rotated, for example, 90° or 180° with respect to the posture of components at the component feed position). For example, the placing operation of the prior art includes firstly doing component suction, then moving to the recognition position, where component recognition is done, then moving to the placing position, where turning operation to the placing posture angle and turn correction operation based on a recognition result are done, and finally doing the placing operation. In such operation, the turning operation to the placing

posture angle (e.g., 90° or 180°) can be done only after the recognition. The reason of this is that because multiple nozzles 304 are operated with one turn-actuating motor 311, adding the turning operation of 180°, 0°, 90° or the like before recognition would cause the throughput to decrease. In addition, when effects of eccentricity, distortion (see Fig. 17B), thermal deformation, and the like of the nozzles 304 are involved, there is another issue that large turning angle of the nozzles 304 would result in proportionally large errors.

④ Batch suction of components different in component thickness is difficult to do; that is, because multiple nozzles 304 are moved up and down with the same up-and-down motor 312, it is impossible to adjust the suction height for individual nozzles 304 as shown in Fig. 17A. Therefore, as shown in Figs. 22 and 18, the nozzles 304 are adjusted in position by contracting springs 360, which are provided for the individual nozzles 304, to an extent corresponding to the thickness differences of the components 320 to thereby absorb the thickness differences of components 320. However, the force exerted onto the components 320 with the springs 360 has limitations so as not to meet large differences in component thickness. Further, control responsive to component thicknesses (load control) is impossible, and adjustment to a recognition height H01 is

unachievable in the component recognition as shown in Fig. 17A.

⑤ For example, with a large turning angle such as 90° and 180°, when turning operation is done after recognition, the throughput would decrease as a whole of mounting operation.

Such various issues of the prior art as described above can all be solved by the first embodiment as follows.

That is, since each suction nozzle 10 is equipped with actuators capable of performing up-and-down operation and turning operation, i.e., a nozzle up-and-down device 26 and a nozzle turning device 25, respectively, the load on one actuator can be reduced, so that the mounting head 4 having such actuators mounted thereon can improvement the operating acceleration without increasing the size of the motor. As a result of this, improvement in the throughput can be accomplished so that the prior-art issues of ① and ② can be solved.

Also, since the nozzles 10 can be subjected to turning operations about the θ-axes at any arbitrary timings, independently of one another, by their respective nozzle turning devices 25, it is possible that with placing posture angles of components being largely different from the component posture angle at the component feed position by 90°, 180° or the like, components can preliminarily be

turned to their placing posture angles by driving the nozzle turning devices 25 after component sucking and holding is performed by the nozzles 10 and before component recognition is performed. As a result of this, all the components are located at their placing posture angles before the component recognition, thus reducing the turning amount for correction subsequent to the recognition so that adjustment to the placing posture angles can be accomplished with proportionally higher precision.

Also, effects of distortions due to thermal changes of the nozzles 10 or the like (see differences between solid-line nozzle 304 and broken-line nozzle 304 in Fig. 17B) can be minimized, so that the placing precision can be improved. More specifically, assume that with the nozzle 10 under no effects of heat or the like, as shown in Fig. 23A, a center 9p of a quadrilateral image 9i of the recognition camera 9 and a center 10p of the nozzle 10 are coincidently located at a position [Xn, Yn] in X-Y coordinates, and that a center 20c of a rectangular-parallelopiped component 20 sucked by the nozzle 10 is located at a position [Xp, Yp] in the X-Y coordinates with a shift from the center 10p of the nozzle 10. Further assume that when the nozzle 10 is turned by $\theta = 45$ degrees about the nozzle axis in this state, the center 20c of the component 20 sucked by the nozzle 10 is located at a

position [Xp', Yp'] in the X-Y coordinates. Then, the X-Y coordinates [Xp', Yp'] of the center 20c of the component 20 resulting after the 45 degree turn can be determined by the following equation (Eq. 1):

Eq. 1:

$$\begin{bmatrix} Xp' \\ Yp' \end{bmatrix} = \begin{bmatrix} \cos\theta & \sin\theta \\ -\sin\theta & \cos\theta \end{bmatrix} \left[\begin{bmatrix} Xp \\ Yp \end{bmatrix} - \begin{bmatrix} Xn \\ Yn \end{bmatrix} \right] + \begin{bmatrix} Xn \\ Yn \end{bmatrix}$$

Next, in the case where the nozzle 10 is under effects of heat or the like, assume that the center 9p of the quadrilateral image 9i of the recognition camera 9 and the center 10p of the nozzle 10 are not coincident with each other as shown in Fig. 23B, where the nozzle 10 is distorted due to the effects of heat or the like so as to be shifted with respect to the position [Xn, Yn] in the X-Y coordinates of the center 9p of the image 9i so as to be located at a position [Xn', Yn'] in the X-Y coordinates. Further assume that the center 20c of the rectangular-parallelopiped component 20 sucked by the nozzle 10 is located at the position [Xp, Yp] in the X-Y coordinates with respect to the center 10p of the nozzle 10. When the nozzle 10 is turned by $\theta = 45$ degrees about the nozzle axis in this state, it would be expected that without any effects of heat, the center 20c of the component 20 sucked by the nozzle 10 is located at the position [Xp', Yp'] in

the X-Y coordinates as in the case of Fig. 23A. However, actually, since the actual X-Y coordinates of the turning center 10p of the nozzle 10 have been shifted from [Xn, Yn] to [Xn', Yn'] because of the effects of heat on the nozzle 10, the calculative X-Y coordinates [Xp', Yp'] of the position of the center 20c of the component 20 with respect to the actual X-Y coordinates [Xn', Yn'] of the turning center 10p of the nozzle 10 can be determined by the following equation (Eq. 2):

Eq. 2:

$$\begin{bmatrix} Xp' \\ Yp' \end{bmatrix} = \begin{bmatrix} \cos\theta & \sin\theta \\ -\sin\theta & \cos\theta \end{bmatrix} \left[\begin{bmatrix} Xp \\ Yp \end{bmatrix} - \begin{bmatrix} Xn \\ Yn \end{bmatrix} \right] + \begin{bmatrix} Xn \\ Yn \end{bmatrix}$$

Also, assuming that the calculative turning-center position, i.e., the center 9p of the image 9i is [Xn, Yn] in the X-Y coordinates, the actual X-Y coordinates [Xp_r', Yp_r'] of the position of the component center 20c can be determined by the following equation (Eq. 3):

Eq. 3:

$$\begin{bmatrix} Xp\_r' \\ Yp\_r' \end{bmatrix} = \begin{bmatrix} \cos\theta & \sin\theta \\ -\sin\theta & \cos\theta \end{bmatrix} \left[\begin{bmatrix} Xp \\ Yp \end{bmatrix} - \begin{bmatrix} Xn' \\ Yn' \end{bmatrix} \right] + \begin{bmatrix} Xn' \\ Yn' \end{bmatrix}$$

Therefore, a shift between the calculative X-Y coordinates of the position of the center 20c of the component 20 and the actual X-Y coordinates of the position

of the component center 20c results in a placing position shift, where this placing position shift can be determined by the equation (Eq. 4) from the equations (Eq. 2) and (Eq. 3):

Eq. 4:

$$\begin{bmatrix} Xp' \\ Yp' \end{bmatrix} - \begin{bmatrix} Xp\_r' \\ Yp\_r' \end{bmatrix} = \underbrace{\begin{bmatrix} \cos\theta & \sin\theta \\ -\sin\theta & \cos\theta \end{bmatrix} \left(-\begin{bmatrix} Xn \\ Yn \end{bmatrix} + \begin{bmatrix} Xn' \\ Yn' \end{bmatrix} \right)}_{\theta\text{-dependent components}} + \underbrace{\left(\begin{bmatrix} Xn \\ Yn \end{bmatrix} - \begin{bmatrix} Xn' \\ Yn' \end{bmatrix} \right)}_{\text{Translational components}}$$

In this equation (Eq. 4), without any turn of the nozzle 10, i.e., with the turning angle $\theta = 0$, there results zero error, eliminating the placing position shift. In contrast to this, with the nozzle 10 turned, i.e., with the turning angle $\theta \neq 0$, there occurs an error, where the smaller the turning angle θ, the smaller the error. Accordingly, by turning the nozzle 10 before recognition to thereby turn the component 20 to the placing posture angle, allowing the component to be recognized, and then by turning the component to an extent corresponding to the correction after the recognition, the resulting turning angle can be reduced so that errors due to effects of heat or the like can be reduced.

Thus, the prior-art issue of ③ can be solved.

Also, based on information as to the nozzles 10 and the thicknesses of components to be sucked by the

nozzles 10 stored in the memory 910, up-and-down amounts for the individual nozzles 10 by the nozzle up-and-down devices 26 are adjusted under the control of the main controller 1000, the head controller 1001, and the servo drivers 1002, by taking into consideration the thicknesses of the components to be sucked. Thus, even with largely different thicknesses of components, performing the batch suction of a plurality of components 20 by a plurality of nozzles 10 never causes damage to the components 20. Also, based on the information as to the nozzles 10 and the thicknesses of components to be sucked by the nozzles 10 stored in the memory 910, and under the control of the main controller 1000, the head controller 1001, and the servo drivers 1002, up-and-down amounts for the individual nozzles 10 are adjusted by the nozzle up-and-down devices 26 so that the bottom faces of the components sucked by the individual nozzles 10 are adjusted to a uniform height or to within a certain range. Thus, batch recognition of components that are largely different in height from one another is enabled. Therefore, the prior-art issue of ④ can be solved.

Further, as a result of driving the θ-axis motor 25m under the control of the main controller 1000, the head controller 1001, and the servo drivers 1002, the individual nozzles 10 are allowed to perform turning operations about

the θ-axes at any arbitrary timing independently of one another. Therefore, even when the placing posture angle of a component 20 is largely different from its placing angle at the component feed position by, for example, 90° or 180°, any decrease in mounting cycle time can be prevented by, after the sucking and holding of the component 20 with the nozzle 10 and before the recognition of the component 20, driving the nozzle turning device 25 to preliminarily turn the component 20 to its placing posture angle, as compared with the case where the turning operation is performed after the recognition and before the placing. Therefore, the prior-art issue of ⑤ can be solved.

Also, in each component suction device 15, the nozzle turning device 25 and the nozzle up-and-down device 26 for the suction nozzle 10 are provided by the same unit in an arrangement that the θ-axis motor 25m for the nozzle turning device 25 is located below the linear motor 32, which is an up-and-down motor for the nozzle up-and-down device 26, and that the center line of the θ-axis motor 25m is located at the center of thrust occurring to the linear motor 32. Thus, occurrence of unnecessary moment is prevented during up-and-down operations, by which swings due to the up-and-down operations can be prevented.

Also, the nozzle up-and-down device 26 is so structured that the magnetic-circuit forming member 26a and

the mechanism forming member 26b are dividedly provided, where those members can be made of different materials and combined together so that the magnetic-circuit forming member 26a alone is made of steel material and the mechanism forming member 26b is made of aluminum alloy or the like, thus making it possible to reduce the weight and thickness of the device.

Also, the main controller 1000 is provided on the component-mounting-apparatus main body, while the head controller 1001 and the servo drivers 1002 are mounted on the mounting head 4 side. In communications from the main controller 1000 through the head controller 1001 to the servo drivers 1002, the same broadcast communications can be performed to the servo drivers 1002 for all the nozzles 10 by transmitting addresses and drive amounts of the servo drivers 1002. Each of the servo drivers 1002 is enabled to fetch only information coincident with its own address and neglect the other information, thus capable of driving and controlling their respective motors 32, 25m without any malfunction. Thus, communication traffic and communication time can be reduced as compared with the case where communications are performed for each of the servo drivers 902.

Also, values of speed and acceleration for the individual nozzles 10, for example, eight kinds of

specified values are preliminarily transmitted from the main controller 1000 to the head controller 1001 so as to be stored as a table in the memory 1005 connected to the head controller 1001. As a result of this, only transmitting, for example, one specified value selected out of the eight kinds, allows the individual nozzles 10 to operate at a desired speed or acceleration. Thus, communication traffic and communication time can be reduced as compared with the case where concrete information as to speed and acceleration is transmitted.

Further, only by transmitting a command for instructing suction operation by the nozzles 10 or a command for instructing placing operation by the nozzles 10 and travel amount as well as dead-point time for each operation from the main controller 1000 to the head controller 1001, relevant motors 32 or 25m can be driven and controlled via the head controller 1001 by the servo drivers 1002 to perform the suction operation or placing operation. Thus, communication traffic and communication time can be reduced as compared with the case where information as to suction or placing operation is transmitted.

It is noted here that the present invention is not limited to the above embodiment, and may be embodied in other various ways.

For example, the above embodiment has been described on a case where simultaneous suction, simultaneous recognition and the like are done at a time by ten nozzles 10. However, in the case where only five nozzles 10 are used for mounting operation even with ten nozzles 10 mounted on the mounting head 4, it is possible to read the above description by replacing the ten nozzles 10 with five nozzles 10. That is, a plurality of nozzles 10 which should perform mounting operation can be made to simultaneously perform the suction, turning, recognition, or other operations.

The component mounting apparatus equipped with the above-described component suction device is not limited to the above first embodiment, and may be applied to other component mounting apparatuses.

For example, as a component mounting apparatus according to a second embodiment of the present invention, as shown in Figs. 19, 20, and 21, the component mounting apparatus may be one in which mounting heads 4A move only in the X-direction, while a board holding device 3A that holds the board 2 moves only in the Y-direction, without being limiting to those in which the mounting head 4 moves in the X- and Y-directions. More specifically, the board holding device 3A is implemented by a Y-table that advances and retreats only in the Y-axis direction, while an X-axis

driver device 5A extending in the X-axis direction perpendicular to the Y-axis direction is provided. In the X-axis driver device 5A, the mounting heads 4A are driven only in the X-axis direction independently of one another. Also in such a component mounting apparatus, as in the component mounting apparatus of the first embodiment, the nozzles 10 that have sucked the components 20 can be turned at any arbitrary timings to desired angles by the nozzle turning devices 25, and besides the nozzles 10 can be moved up and down at any arbitrary timings to desired heights by the nozzle up-and-down devices 26. Therefore, for example, after the component suction operation at a component feed cassette 8D, the nozzles 10 can be turned to their respective placing posture angles at a time by the drive of the nozzle turning devices 25. Also, before placing, the nozzles 10 can be turned to the their respective correction angles at a time by the drive of the nozzle turning devices 25. In addition, in Fig. 20, reference numeral 1A denotes an unloader, and 11A denotes an unloader.

A component suction device according to a third embodiment of the present invention, as shown in Figs. 24 and 25, includes: a drive shaft 500 which is movable up and down and turnable about its axis; a suction nozzle 10A which is fitted at a lower end of the drive shaft 500 so as to be relatively unturnable and up-and-down relatively

immovable, and which can suck and hold the component 20; a θ-turn driving motor 25A which is connected to an upper portion of the drive shaft 500 so as to be up-and-down relatively movable and relatively unturnable, and which turns the drive shaft 500 about its axis; an up-and-down driver device 26A which has a cylindrical first coupling section 501 connected to the drive shaft 500 up-and-down relatively immovably and relatively turnably, and which drives up and down the first coupling section 501 to thereby drive the drive shaft 500 up and down; a driver 1002A which drives and controls the θ-turn driving motor 25A and the up-and-down driver device 26A independently of each other; and a suction control valve 580 which controls the suction operation of the nozzle 10A. The component suction device of such a constitution is provided side by side in a plural number on a mounting head 4C.

As shown in Figs. 26 and 27, the drive shaft 500 has, in upper part thereof, a spline shaft portion 500a having a pair of recessed portions 521 at an interval of, for example, 180 degrees. Outside the spline shaft portion 500a, are fitted a cylindrical second coupling section 502 which has a pair of protrusions 520 for engaging with a pair of recessed portions 521 of the spline shaft portion 500a and which is up-and-down relatively movable and relatively unturnable. Further outside the second coupling

section 502, is fitted a lower end portion of an elongate, cylindrical third coupling section 25C which is connected relatively unturnably with a key 503 fitted into a keyway 523 of the second coupling section 502. An upper end of the third coupling section 25C is fixed to a turning shaft 540 of the θ-turn driving motor 25A.

Therefore, as the turning shaft 540 of the θ-turn driving motor 25A is driven to turn, the third coupling section 25C, the second coupling section 502 coupled to the third coupling section 25C relatively unturnably, the drive shaft 500 having the spline shaft portion 500a connected to the second coupling section 502 relatively unturnably, and the nozzles 10A connected to the lower end of the drive shaft 500 integrally turn.

Also, the cylindrical first coupling section 501 connected to the drive shaft 500 up-and-down relatively immovably and relatively turnably is connected to the up-and-down driver device 26A via a drive arm 510. By the drive of the up-and-down driver devices 26A, the drive arm 510, the first coupling section 501 connected to the drive arm 510, the drive shaft 500 connected to the first coupling section 501 up-and-down relatively immovably, and the nozzle 10A fixed to the lower end of the drive shaft 500 integrally move up and down. The distance of this move is, as shown in Figs. 29 and 30, between an upper-end

position H0 and a lower-end position H1, for example, about 20 mm.

As shown above, the up-and-down driver device 26A is located not coaxial with the drive shaft 500 but beside the drive shaft 500 so as to move up and down the drive shaft 500 via the drive arm 510. Therefore, heat generated by the up-and-down movement of the up-and-down driver device 26A is less likely to be transferred to the drive shaft side, so that the drive control by the drive shaft 500 can be enhanced and that the structure as a whole can be simplified.

The nozzles 10A are so arranged that the width of the component suction devices, i.e., the array pitch of the θ-turn driving motors 25A, the array pitch of the rectangular up-and-down driver devices 26A, and the width of the rectangular drivers 1002A are a pitch distance corresponding to the array pitch of a plurality of component feed sections of the component feed device, for example, component cassettes, trays, or the like. As a result of this, it becomes possible to once locate a plurality of nozzles 10A above a plurality of component cassettes or trays and then move them down, thus making the nozzles 10 to perform batch suction simultaneously. Thus, the width of the mounting head 4C can be minimized by setting the widths of the individual rectangular motors 25A,

26A and rectangular drivers 1002A according to the array pitch of the nozzles 10A. Also, when the rectangular motors or drivers are fitted to the mounting head 4, it is possible to fix them in contact with one another by virtue of their rectangular shape, in which case the rigidity can be improved.

The θ-turn driving motor 25A has an encoder 25B on top thereof so as to be able to detect the turning angle of the turning shaft 540. An output from the encoder 25B is fed to the driver 1002A, and the θ-turn driving motor 25A is driven and controlled by the drive shaft 500 at the turning angle based on the turning angle position of the nozzle 10A.

The up-and-down driver device 26A can be implemented by a voice coil motor as an example. As shown in Fig. 26, the up-and-down driver devices 26A is made up generally of a movable magnet 511 which can be moved up and down by a pair of up-and-down extending linear guides 513 and to which the drive arm 510 is fixed, four coils 512, and a linear scale 514 which detects the vertical position of the movable magnet 511 with high precision. The vertical position information determined by the linear scale 514 is fed to the driver 1002A, and the up-and-down driver 26A is driven and controlled based on this positional information.

This third embodiment is characterized by the following features.

1. A plurality of nozzles 10A are equipped with laterally opposed θ-motors 25A controllable independently of one another, respectively, as an example of the θ-turn driving motor 25A.

2. In the constitution of the above paragraph 1, the nozzles 10A can be moved up and down via the drive shafts 500.

3. In the constitution of the above paragraph 1, the nozzles 10A can be moved up and down by the thin type voice coil motors (VCMs) as an example of the up-and-down driver device.

4. In the constitution of the above paragraphs 1 and 3, the drivers 1002A that control the motors 25A, 26A are attached near the above constitutions, where with a method of operating from the host in serial communications, the wiring can be saved by mounting the head controller on a movable section.

5. In the constitutions of the above paragraphs 1 to 4, there is such a characteristic arrangement (where ten nozzles 10A are adjusted to a minimum pitch of the component cassettes; by mounting the head controller on a movable section and by adjustment to the minimum cassette pitch, reduction in size and weight is implemented) that

the motors 25A, 26A and the drivers 1002A are thinned so as to be adjusted to the width of the component cassettes as an example of the component feed section. As a result of this, the weight as a whole of the mounting head 4C can be reduced to a half, and vibrations occurring with movement can be reduced to a large extent.

6. In the constitution of the above paragraph 5, the suction opening-and-closing valve of the nozzle 10A is attached for each of the nozzles 10A, where the components can be sucked and placed independently or simultaneously. That is, with the head controller mounted on the movable section, high-speed machine operation is performed by several I/O units.

7. In the constitution of the above paragraph 1, it is characterized in that after the component suction and placing, one turn is made so that bearings 530, 531, 532, 533 or the like are prolonged in life. That is, after the end of suction and before move to next step, the nozzle 10A is subjected to one turn, thereby prolonged in life.

This is explained below.

First, in the case where up-and-down moves and a θ turn are performed when placement is performed after component suction and recognition, as in the prior-art apparatuses, it is impossible to reduce the mounting cycle time because the two operations of the up-and-down moves

and the θ turn are performed. That is, since a plurality of nozzles are turned with one θ-motor, the individual nozzles cannot be θ-turned to the respective placement positions before being recognized, and instead the up-and-down move and θ-turn are performed at the time of placing, thus making it unattainable to reduce the mounting cycle time. However, according to the third embodiment, after component suction and during the move to the recognition position, individual nozzles can be θ-turned to the their respective placed-state positions and then recognized, and thereafter subjected corrective turns for the θ-turn positions during move to the placing positions, and then component placing only by up-and-down move can be performed. Thus, reduction in the mounting cycle time can be realized. Also, since the nozzles 10A can be adjusted in placing orientation, i.e., to their θ-turn positions before being recognized, so that the placing precision can be improved.

Next, in the case of prior-art apparatuses in which head-driving actuators are mounted within the mounting head and drivers, which are controllers therefor, are mounted on the equipment main body, increasing the number of head-driving shafts would cause the wiring for connecting the heads and the equipment machine body to increase. However, in the third embodiment, the motors adjusted to the pitch of the nozzles 10A of the mounting

head 4C (laterally opposed θ-motors 25A as an example of the θ-turn driving motors and thin-type voice coil motors 26A as an example of the up-and-down driver devices), as well as motor drivers therefor, are mounted on the mounting head 4C, and the conventional NC controller is mounted on the mounting head 4C, where the equipment machine body and the driver controller are communicated with each other by wired or wireless communications. As a result of this, even if the number of nozzle shafts of the mounting head 4C is increased, the wiring between the equipment machine body and the mounting head 4C is not increased.

Next, in the prior-art apparatuses, the θ-motors, being unable to be coaxial with the center axes of the nozzles, and then the rotary forces thereof are transferred to the center axes of the nozzles with rack and pinion or with timing belt, where large error factors such as backlash are involved. That is, in the case where the nozzle pitch is adjusted to a minimum pitch of component cassettes, it would be impossible to provide θ-motors for individual nozzles, respectively, and the θ-turn is implemented by belt or by rack and pinion. As a result of this, turn errors such as backlashes of gears would be large. In contrast to this, according to the third embodiment, the laterally opposed θ-motors 25A are disposed coaxial with the nozzles 10A, and turns are transferred via

the spline shafts 500. That is, the laterally opposed θ-turn driving motors 25A serving as thin-type servomotors are located coaxial with the center axes of the individual nozzles 10A, by which turning force in the θ-direction can be transferred directly to the nozzles 10A, so that turning errors can be reduced.

Also, in the prior-art constitution, as shown in Fig. 35, in the case where the back turn for the nozzle 10, which is performed after the θ-turn from its initial angle position ORG to the placing angle position X1 in order to return the nozzle 10 to the initial position, is set to a turn equal in angle value(-θ) and opposite in direction to the turn to the placing angle position X1 (θ-turn) as shown in Fig. 36 for the purpose of speedup of the cycle time, loads would be applied to the same portions or same balls of the bearings, which causes the bearings to be shortened in life. Further, when the nozzle 10 is moved for correction turn in the placing at 0°, it becomes more likely that fretting occurs to the bearings, causing the bearings to be shortened in life. In contrast to this, in the third embodiment, in the case where the back turn for the nozzle 10A, which is performed after the θ-turn from its initial angle position to the placing angle position in order to return the nozzle 10A to the initial position, is set to a turn of a (360°-θ) angle equal in direction to the

turn to the placing angle position (θ-turn) as shown in Figs. 37 and 38, by which the nozzle 10 is returned to the initial angle position, the nozzle 10 is turned 360° in all cases, making use of all the balls of the bearings 530, 531, 532, 533 as shown in Fig. 26. As a result of this, the bearings 530, 531, 532, 533 are subjected to one turn in all cases, so that loads are applied uniformly to all the balls, allowing the bearings 530, 531, 532, 533 to be prolonged in life. It is noted that the bearings 530, 531 are bearings which rotatably support upper and lower portions of the turning shaft 540 of the θ-turn driving motor 25A. The bearings 532, 533 are bearings which rotatably support upper and lower portions of the third coupling section 25C.

A θ-turn driving motor 25A according to a third embodiment of the present invention is explained below with reference to Figs. 39 to 44.

Before the explanation of the θ-turn driving motors 25A according to the third embodiment of the present invention proceeds, a conventional brushless motor is first explained as an example.

The conventional brushless motor is so constructed that, as shown in Fig. 45, a rotor 101 is placed at the center, with an annular stator 102 surrounding the rotor 101. The rotor 101 is magnetized to

a plurality of poles peripherally. Each of teeth 102a - 102f of the stator 102 is wound with a coil 103, and fore ends of the teeth 102a - 102f are close to the outer periphery of the rotor 101 with a gap δ.

In this case, a case of three phase (UVW) is shown, where the position of the rotor 101 is detected by a separate sensor (not shown), and energization timings to the coils 103 of individual phases, UVW, are controlled in response to the position of the rotor 101 so that a rotating magnetic field is generated from the stator 102 to thereby drive the rotor 101 into rotation.

Also, there has conventionally been provided, in need for smaller size, a coreless motor in which, as shown in Fig. 46A, 46B, a coreless motor is so constructed that coreless coils 103 are placed around a rotor 101, with a stator yoke 104 placed on the outer periphery of the coils 103, where a rotating magnetic field is generated to drive the rotor 101 into rotation as in the case of Fig. 45.

However, the coreless motor is, on one hand, capable of being downsized, as compared with the normal brushless motor shown in Fig. 45, and on the other hand, poor at magnetic efficiency because of its having no iron core, thus resulting in an issue that high torque output cannot be achieved. Further, an attempt to obtain as high torque as possible would only cause the rotor 101 and the

coils 103 to be made longer in length in the axial direction of the rotor 101 (Y-axis direction), hence low degree of freedom of design as it stands.

(First Example)

Thus, as a first example of the θ-turn driving motor 25A according to the third embodiment of the present invention, its object is to provide a brushless motor which can be downsized more than the brushless motor shown in Fig. 45, and yet which is better at magnetic efficiency and higher in torque output than the coreless motor.

Figs. 39 to 42 show the brushless motor according to the third embodiment of the present invention.

The brushless motor according to the third embodiment of the present invention, as shown in Fig. 39, is assembled of a rotor 101, generally flat first, second stator blocks 105a, 105b, a holder body 106, and a holder plate 107, a main part of which is shown in Fig. 40.

The rotor 101 is magnetized peripherally to a plurality of poles. Each of the first, second stator blocks 105a, 105b, as shown in Fig. 41, is made by laminating a plurality of magnetic steel plates each punched out into a generally E-shape form, and having three teeth 108a, 108b, 108c. Fore ends of the teeth are formed into a circular arc shape running along the outer periphery of the rotor 101. Each of the teeth 108a, 108b, 108c is

wound with a coil 103, where portions of the teeth at which the coils 103 are wound are referred to tooth winding portions 109. Winding grooves 110 are formed at the tooth winding portions 109 of the teeth 108a, 108c.

Concretely, fore ends of the teeth 108a - 108c are so formed that circular-arc surfaces confronting the outer periphery of the rotor have a symmetrical 60° slot pitch as shown in Fig. 41.

In the electric circuit, the position of the rotor 101 is detected by a separate sensor (not shown) such as magnetic sensor, and energization timings to the coils of individual phases, UVW, are controlled in response to the position of the rotor 101 so that a rotating magnetic field is generated from the stators 105a, 105b to thereby drive the rotor 101 into rotation.

Like this, the stator has a thickness by laminating magnetic steel plates along the axial direction of the rotor 101 (the Y-direction in Fig. 41), with the teeth 108a - 108c parallel to one another, and the shape along the end face of the rotor is such a flat type one that a first length L1 formed by connecting 0° and 180° to each other about the axis (X-axis direction shown in Fig. 41) is shorter than a second length L2 formed by connecting 90° and 270° to each other (Z-axis direction shown in Fig. 41). Thus, this brushless motor is smaller in size, and

successful in magnetic efficiency because of no coreless motor, as compared with the conventional brushless motor shown in Fig. 45.

Further, larger output torque can be attained by setting longer the tooth winding portions 109 of the teeth 108a - 108c in the Z-axis direction as shown in Fig. 41 to thereby enhance the magnetic field, or by forming longer the rotor 101 and the stator blocks 105a, 105b in the Y-axis direction as shown in Fig. 41, wherever it is at least either one of these two ways. Thus, whereas the degree of freedom for designing the conventional coreless motor shown in Fig. 46 is in one way of the Y-axis direction, the degree of freedom of design can be given in two ways of the Y-axis direction and the Z-axis direction in this third embodiment, so that necessary torque can be outputted with an appropriate form suited to applications.

Also, in the case where the winding grooves 110 to serve as the tooth winding portions 109 are formed thicknesswise (in the Y-axis direction) on a side surface 111 crossing the direction of the first length of the first, second stator blocks 105a, 105b as described above, and where an outermost peripheral surface 112 of the coils 103 wound on the winding grooves 110 is positioned so as to be flush with the side surface 111 or inner than the side surface, the width of the brushless motor in the X-axis

direction can be further reduced.

(Second Example)

Fig. 43 shows a brushless motor, which is a second example of the θ-turn driving motor 25A according to the third embodiment of the present invention.

The flat-type stators of the brushless motor according to this second example are constructed by first, second stator blocks 105a, 105b that come into contact with each other at a boundary that connects 0° and 180° about the axis. This second example, as shown in Fig. 43, differs from the first example only in that the stator is constructed by a single stator block 112, the rest of the constitution being the same as in the first example.

(Third Example)

Fig. 44 shows a brushless motor, which is a third example of the θ-turn driving motor 25A according to the third embodiment of the present invention.

Whereas first, second stator blocks 105a, 105b of the brushless motor according to the third example have been constructed by forming three teeth 108a - 108c in each one block, it is also possible that tooth blocks 113a, 113b, 113c as shown in Fig. 44A are come into contact with and joined together at joints 114 so as to form magnetic paths at both end portions of the tooth winding portions 109 as shown in Fig. 44B. Otherwise, the brushless motor is the

same as the third embodiment.

In this case, the work of winding the coils on the tooth winding portions 109 becomes easier.

As shown above, in the brushless motor as a θ-turn driving motor 25A according to the third embodiment of the present invention, the fore ends of the individual teeth of the stators are formed into circular-arc surfaces extending along the outer periphery of the rotor, and the individual teeth winding portions are formed parallel to one another. Thus, as compared with the conventional brushless motor in which the rotor is surrounded by an annular stator, the brushless motor can be made smaller in size than the brushless motor shown in Fig. 45, and yet the brushless motor can be made better in magnetic efficiency and higher in torque output than coreless motors.

An up-and-down driver device 26A according to the third embodiment of the present invention is described below with reference to Figs. 47 to 52.

Before the explanation of the up-and-down driver device 26A according to the third embodiment proceeds, a conventional voice-coil type linear motor is first described as an example in terms of its issues.

Fig. 53 shows a basic voice-coil type linear motor.

In this voice-coil type linear motor, magnets

201a, 201b as stationary-side ones are located on the lower side, and a frame coil 202 is located on its upper side with gaps from the magnets 201a, 201b so as to be movable left and right in this case of Fig. 53. In the magnet 201a, its face opposite to the frame coil 202 is magnetized to the N pole. In the magnet 201b, its face opposite to the frame coil 202 is magnetized to the S pole.

When electric current is passed through the frame coil 202 in the direction of arrows, the magnetic action of the magnets 201a, 201b and a magnetic field generated in a vertical interval 202v of the frame coil 202 causes the movable-side frame coil 202 to be driven by a distance Y to the right side, in this case, against the magnets 201a, 201b.

Fig. 54 shows a case of three phases (UVW), where a magnet 201a magnetized to the N pole, a magnet 201b magnetized to the S pole, a magnet 201c magnetized to the N pole, and a magnet 201d magnetized to the S pole, all of which are so magnetized at their upper surfaces, are placed at specified intervals on the stationary side, and over these members, frame coils 202a, 202b, 202c are located on the movable side, movable left and right in this Fig. 54, with gaps provided to the magnets 201a - 201d on the upper side.

When electric current is passed through the frame

coils 202a, 202b, 202c, the same magnetic action as described above causes the movable side to be driven, in this case, laterally.

As another example of the prior art, magnets 201a, 201b are fitted on both sides of a center pole 203 as shown in Fig. 55, a yoke 204 is provided so as to surround outer peripheral portion thereof, and a frame coil 205 is disposed on the yoke 204, which is the movable side, so as to surround the center pole 203. An attraction-and-repulsion action of a magnetic field generated by passage of electric current through the frame coil 205 and generated magnetic fields A1, A2 of the magnets 201a, 201b causes the movable side to move in a direction vertical to the drawing sheet of Fig. 55.

In the above structures of the prior art as described above, in all cases, span section X of the frame coils 202a - 202c and 205 do not contribute to the thrust but result in a loss. Also, in the type shown in Fig. 55, the magnetic flux is concentrated to the center pole 203 so that magnetic saturation is more likely to occur, posing an issue that high torque output is unattainable.

The up-and-down driver device 26A according to the third embodiment of the present invention is purposed to provide a linear motor of higher thrust than conventional counterparts. That is, the up-and-down driver

device 26A according to this third embodiment is a linear motor which is driven into slide in such a direction that stationary side and movable side located in opposition to each other are prevented from changing in the gap of the opposition by the magnetic action.

(First Example)

Figs. 47 to 50 show a linear motor which is a first example of the up-and-down driver device 26A according to the third embodiment of the present invention. It is noted that although the linear motor for actual use is made up of four coils 512 for larger thrust, the following description is made on a case of two coils. Also in the following description, the coils 512 correspond to the first, second teeth 209a, 209b. A pair of linear guides 513 correspond to the guide rails 214a, 214b. A movable-side member (e.g., the outer yoke 206) corresponds to the movable magnet 511.

This linear motor according to the first example is an internal-magnet type linear motor, in which frame coils 207a, 207b are provided inside an outer yoke 206 on the stationary side. Guide rails 214a, 214b are provided on side faces of the outer yoke 206, and sliders 208a, 208b are movably fitted to the guide rails 214a, 214b. Support arms 210a, 210b of an inner yoke 209, which is the movable side, are attached with screws 215a on one-side ends of the

sliders 208a, 208b as shown in Fig. 48, and the inner yoke 209 is supported so as to be slidable in such directions as to pass through the cylindrical outer yoke 206 (directions of arrows J1, J2). Also, a back yoke 216 is attached with screws 215b to the other-side ends of the sliders 208a, 208b.

The inner yoke 209 is of such a U-shape that the first, second teeth 209a, 209b are connected to each other with a base-end magnetic communicating portion B. As shown also in Fig. 49, S poles that are one-side poles of the first, second magnets 211a, 211b are stuck to upper and lower surfaces of the first tooth 209a, respectively, so that the upper and lower surfaces are made into N poles, while N poles that are the other-side poles of third, fourth magnets 211c, 211d are stuck to upper and lower surfaces of the second tooth 209b, respectively, so that the upper and lower surfaces are made into S poles.

The frame coil 207a is provided inside the outer yoke 206 so as to surround the exterior of the first tooth 209a with a gap, and the frame coil 207b is provided inside the outer yoke 206 so as to surround the exterior of the second tooth 209b with a gap.

Further, fore ends of the first, second teeth 209a, 209b are inserted into recessed portions 217a, 217b of the back yoke 216 and further engaged with screws 215c

as shown in Fig. 48, where the back yoke 216 serves as the magnetic communicating portion B. In this way, the linear motor according to the first example is assembled.

With the constitution as described above, as shown in Fig. 50, a magnetic flux $\phi 1$ radiated from the N pole of the first magnet 211a flows toward the second tooth 209b adjoined by the outer yoke 206, flowing into the S pole of the third magnet 211c, further flowing from the N pole of the third magnet 211c into the second tooth 209b, further flowing from the second tooth 209b via the magnetic communicating portion B into the first tooth 209a, reaching the S pole of the first magnet 211a. The magnetic flux $\phi 1$ flows in circulation.

Similarly, a magnetic flux $\phi 2$ radiated from the N pole of the second magnet 211b flows toward the second tooth 209b adjoined by the outer yoke 206, flowing into the S pole of the fourth magnet 211d, further flowing from the N pole of the fourth magnet 211d into the second tooth 209b, further flowing from the second tooth 209b via the magnetic communicating portion B into the first tooth 209a, reaching the S pole of the second magnet 211b. The magnetic flux $\phi 2$ flows in circulation.

In this state, with electric current passed through the frame coils 207a, 207b in a direction shown in Fig. 50, magnetic fields generated by the frame coils 207a,

207b act on the magnetic fluxes $\phi1$, $\phi2$, causing the inner yoke 209 to be moved along the direction of arrow J1.

In this connection, the frame coils 207a, 207b each have an opening face having such a rectangular shape that a length L1 of its side line opposite to the magnet is longer than a length L2 of its span section X, thus allowing large thrust to be obtained. Still, because the inner yoke 209 has driving force generated at the two members of the first, second teeth 209a, 209b, thrust larger than that of the prior-art system shown in Fig. 55 can be obtained.

Further, the first, second teeth 209a, 209b has less tendency of such magnetic saturation as seen in the constitution of Fig. 55, thus capable of obtaining thrust that changes nearly proportionally over a wide range of strength of magnetic fields generated by the frame coils 207a, 207b. More concretely, in Fig. 55 that shows a prior-art example, magnetic fluxes A1, A2 circulatively flow from the yoke 204 into a small side face 213 of the center pole 203, resulting in magnetic saturation. On the other hand, in the first example, as shown in Fig. 50, magnetic fluxes $\phi1$, $\phi2$ aggressively flow into the upper and lower faces (surfaces on which the first to fourth magnets are arranged) larger in area than the side faces of the first, second teeth 209a, 209b, thus allowing such magnetic

saturation as described above to be reduced to a great extent.

In this first example, the magnetic communicating portion B has been provided at both ends of the first, second teeth 209a, 209b. However, by taking into consideration the assemblability, the magnetic communicating portion B may also be provided at only the base ends of the first, second teeth 209a, 209b, with the other opened.

(Second Example)

Figs. 51 and 52 show a linear motor which is a second example of the up-and-down driver device 26A according to the third embodiment of the present invention.

This linear motor according to the second example is an exterior-magnet type linear motor, in which an outer yoke 206 moves relative to an inner yoke 209.

In the inner yoke 209 having first, second teeth 209a, 209b both ends of which are connected to each other with the magnetic communicating portion B, the outer yoke 206 externally surrounding the first, second teeth 209a, 209b is supported so as to be slidable in the longitudinal direction of the first, second teeth 209a, 209b (direction of arrow J) with a gap.

Inside the outer yoke 206, first, second, third, fourth magnets 211a, 211b, 211c, 211d are provided opposite

to both faces of the teeth so that the faces of the magnets opposed to the teeth are of a single pole different in polarity from the faces opposed to their respective adjoining teeth.

More specifically, as shown in Fig. 52, the S poles of the first, second magnets 211a, 211b are stuck to the opposed faces of the first tooth 209a inside the outer yoke 206 so that one side of the first tooth 209a becomes one polarity, which is the N pole. The N poles of the third, fourth magnets 211c, 211d are stuck to the opposed faces of the second tooth 209b inside the outer yoke 206 so that one side of the second tooth 209b becomes the other polarity, which is the S pole.

A coil 212a is arranged and concentratedly wound on the first tooth 209a, and a coil 212b is arranged and concentratedly wound on the second tooth 209b, where a gap δ is formed between the coil 212a and the first, second magnets 211a, 211b and between the coil 212b and the third, fourth magnets 211c, 211d.

As a result of such a constitution as described above, magnetic fluxes $\phi 1$, $\phi 2$ radiated from the N poles of the first, second magnets 211a, 211b flow through the first tooth 209a toward the magnetic communicating portion B, flowing from the second tooth 209b into the S poles of the third, fourth magnets 211c, 211d, thus reaching from the N

poles of the third, fourth magnets 211c, 211d via the outer yoke 206 to the S poles of the first, second magnets 211a, 211b. Thus, the magnetic fluxes $\phi 1$, $\phi 2$ flow in circulation.

In this state, with electric current passed through the frame coils 212a, 212b, magnetic fields generated by the frame coils 212a, 212b act on the magnetic fluxes $\phi 1$, $\phi 2$, causing the inner yoke 209 to be moved along the direction of arrow J responsive to the direction of the current passage.

In this connection, the first, second teeth 209a, 209b each have such a rectangular shape that a length L3 of its side line opposite to the corresponding one of the first to fourth magnets 211a - 211d is longer than a length L4 of a connection side connecting the opposite sides, so that the coils 212a, 212b wound on these first, second teeth 209a, 209b to be relatively shorter in their span sections X. Thus, as in the first example, a thrust larger than that of the prior-art system shown in Fig. 55 can be obtained.

Although both ends of the teeth 209a, 209b have been connected to each other with the magnetic communicating portion B in this second example, one-side ends thereof may be opened.

In addition, although the two of the first, second teeth 209a, 209b have been provided as the teeth of

the inner yoke 209 in the foregoing examples, yet three or more number of teeth may also be provided in parallel with similar constitution.

As shown above, with the use of the linear motor of the up-and-down driver device 26A according to the third embodiment of the present invention, thrust higher than that of conventional counterparts can be attained by the combination of an inner yoke which has a plurality of teeth with a magnet attached to each of the teeth, and an outer yoke in which frame coils are attached.

Also, with the use of the linear motor of the up-and-down driver device 26A according to the third embodiment of the present invention, thrust higher than that of conventional counterparts can be attained by the combination of an inner yoke which has a plurality of teeth with a coil wound on each of the teeth, and an outer yoke in which magnets are attached.

In addition, combining any arbitrary embodiments from among the foregoing various embodiments, as required, makes it possible to produce their individual effects.

According to the present invention, actuators, or a nozzle up-and-down device and a nozzle turning device, capable of performing up-and-down operations and turn correction for every component suction device, i.e., every suction nozzle, can be provided, so that loads on one

actuator can be reduced. A mounting head on which such actuators are mounted can fulfill an improvement in operating acceleration without increasing the size of the motor. As a result of this, throughput can be improved.

Also, since the nozzles can be subjected to turning operations about the axes at any arbitrary timings, independently of one another, by their respective nozzle turning devices, it is possible that with components whose placing posture angle is largely different from the component posture angle at the component feed position by 90°, 180° or the like, components can preliminarily be turned to their placing posture angles by driving the nozzle turning devices after component sucking and holding is performed by the nozzles and before component recognition is performed. As a result of this, all the components are located at their placing posture angles before the component recognition, thus reducing the turning amount for correction subsequent to the recognition so that adjustment to the placing posture angles can be accomplished with proportionally higher precision. Also, effects of distortions due to thermal changes of the nozzles or the like can be minimized, so that the placing precision can be improved.

Also, based on information as to the nozzles and the thicknesses of components to be sucked by the nozzles,

up-and-down amounts for the individual nozzles by the nozzle up-and-down devices are adjusted by taking into consideration the thicknesses of the components to be sucked for the individual nozzles. Thus, even with largely different thicknesses of components, performing the batch suction of a plurality of components by a plurality of nozzles never causes damage to the components. Also, based on the information as to the nozzles and the thicknesses of components to be sucked by the nozzles, up-and-down amounts for the individual nozzles are adjusted by the nozzle up-and-down devices so that the bottom faces of the components sucked by the individual nozzles are adjusted to a uniform height or to within a certain range. By doing so, batch recognition of components that are largely different in height from one another is enabled.

Further, since the nozzles can be subjected to turning operation, about the axes at any arbitrary timings independently of one another, it is possible that with components whose placing posture angle is largely different from the component posture angle at the component feed position by 90°, 180° or the like, components can preliminarily be turned to their placing posture angles by driving the nozzle turning devices after component sucking and holding is performed by the nozzles and before component recognition is performed. As a result of this,

any decrease in mounting cycle time can be prevented as compared with the case where the turning operation is performed after the recognition and before the placing.

Further, with the nozzle up-and-down device arranged below the nozzle turning device, turning drive of the nozzle turning device would cause the nozzle up-and-down device to turn along with the nozzle, in which case the wiring lines for the nozzle up-and-down device and the like would be complicated in structure. However, in the present invention, since the nozzle up-and-down device is located above the nozzle turning device, turning drive of the nozzle turning device does not cause the nozzle up-and-down device to turn along with the nozzle, in which case such issues as described above do not occur.

Also, in the case where the nozzle up-and-down device is so structured that the magnetic-circuit forming member and the mechanism forming member are dividedly provided, those members can be made of different materials and combined together so that the magnetic-circuit forming member alone is made of steel material and the mechanism forming member is made of aluminum alloy or the like, thus making it possible to reduce the weight and thickness of the device.

Although the present invention has been fully described in connection with the preferred embodiments

thereof with reference to the accompanying drawings, it is to be noted that various changes and modifications are apparent to those skilled in the art. Such changes and modifications are to be understood as included within the scope of the present invention as defined by the appended claims unless they depart therefrom.

CLAIMS

1. A component suction device for sucking a component (20) which is to be mounted onto a circuit-forming body (2), comprising:

a suction nozzle (10) for sucking and holding the component;

a nozzle turning device (25) for holding the suction nozzle and turning the suction nozzle; and

a nozzle up-and-down device (26) which is located upward of the nozzle turning device and which is connected to the suction nozzle to serve for moving up and down the suction nozzle along an axial direction of the suction nozzle.

2. A component suction device according to Claim 1, wherein the nozzle up-and-down device (26) is implemented by an up-and-down linear motor (32) for moving up and down the nozzle turning device (25) along the axis of the suction nozzle, and wherein the nozzle turning device is moved up and down by driving the up-and-down linear motor, whereby the suction nozzle is moved up and down along the axis of the suction nozzle.

3. A component suction device according to any one of Claims 1 to 3, wherein a coil (26c) is up-and-down movable relative to a magnetic-circuit forming member (26a) fixed to a mechanism forming member (26b) of the linear

motor (32) and wherein the nozzle turning device is fixed to a support member (26s) that supports the coil.

4. A component mounting apparatus comprising a mounting head (4) having a plurality of component suction devices (15) as described in any one of Claims 1 to 3, wherein

the nozzle turning devices (25) of the plurality of component suction devices are driven individually and independently of one another, and the nozzle up-and-down devices (26) of the plurality of component suction devices are driven individually and independently of one another.

5. A component mounting apparatus comprising:

a mounting head (4) having a plurality of component suction devices (15) as described in any one of Claims 1 to 3; and

a main controller (1000) for controlling operations of: turning components, which have been sucked and held by the suction nozzles, respectively, of the plurality of component suction devices, to placing posture angles of the individual components by drive of the nozzle turning devices (25); thereafter, recognizing postures of the individual components that have been sucked and held by the suction nozzles and turned to their placing posture angles; correcting the postures based on recognition results; and thereafter mounting the individual components

onto the circuit-forming body (2).

6. A component mounting apparatus according to Claim 4, wherein the main controller (1000) controls to simultaneously turn the components sucked and held by the suction nozzles, respectively, to placing posture angles of the individual components by drive of the nozzle turning devices (25).

7. A component mounting apparatus comprising:

a mounting head (4) having a plurality of component suction devices (15) as described in any one of Claims 1 to 3; and

a main controller (1000) for controlling operations of: simultaneously turning components, which have been sucked and held by the suction nozzles, respectively, of the plurality of component suction devices, to placing posture angles of the individual components by drive of the nozzle turning devices (25); thereafter, placing the individual components, which have been turned to their placing posture angles, onto the circuit-forming body (2).

8. A component mounting apparatus comprising:

a mounting head (4) having a plurality of component suction devices (15) as described in any one of Claims 1 to 3; and

a main controller (1000) for controlling

operation of: immediately after sucking and holding components by the suction nozzles of the plurality of component suction devices, turning the individual components to their respective placing posture angles by drive of the nozzle turning devices (25) of the individual component suction devices individually and independently of one another; and thereafter placing the individual components, which have been turned to their placing posture angles, onto the circuit-forming body (2).

9. A component mounting method for sucking and holding components (20), which are to be mounted onto a circuit-forming body (2), with a plurality of suction nozzles (10) and thereafter placing the sucked and held components onto the circuit-forming body, the method comprising:

turning the individual components, which have been sucked and held respectively by the suction nozzles, to placing posture angles of the components individually and independently of one another;

thereafter, recognizing postures of the individual components that have been sucked and held by the suction nozzles and turned to their respective placing posture angles; and

thereafter, correcting the postures based on recognition results and then placing the individual

components onto the circuit-forming body (2).

10. A component mounting method according to Claim 9, wherein in turning the individual components, which have been sucked and held respectively by the suction nozzles, to placing posture angles of the components individually and independently of one another, the components, which have been sucked and held respectively by the plurality of suction nozzles, are simultaneously turned to the placing posture angles of the individual components.

11. A component mounting method according to Claim 9, wherein in turning the individual components, which have been sucked and held respectively by the suction nozzles, to placing posture angles of the components individually and independently of one another, the individual components are turned to their respective placing posture angles individually and independently of one another, immediately after the sucking and holding of the components by the suction nozzles.

12. A component mounting apparatus comprising:

a mounting head (4) having a plurality of component suction devices (15) as described in any one of Claims 1 to 3;

a main controller (1000) which is located on a component-mounting-apparatus main body and which controls component mounting operation;

a head controller (1001) which is located on the mounting head and connected to the main controller (1000) to perform one-to-one asynchronous communications in serial connection with the main controller in association with drive-control related information; and

a plurality of servo drivers (1002) which are located on the mounting head and connected to the head controller and which perform one-to-multi synchronous communications in serial connection with the head controller in association with drive-control related information and thus drive and control the nozzle up-and-down devices (26) of the individual component suction devices based on resulted drive-control related information obtained from the head controller.

13. A component mounting apparatus according to Claim 12, wherein

the plurality of servo drivers have addresses different from one another; and

the drive-control related information comprises: drive-amount information containing addresses of the servo drivers, and information as to drive amounts for the nozzle up-and-down device or the nozzle turning device; and an operation start signal to be communicated at a timing different from that of the drive-amount information, wherein after the drive-control related information has

been received by the servo drivers having the addresses, the servo drivers, upon receiving the operation start signal, exert control so that the nozzle up-and-down device or the nozzle turning device is driven based on the drive-amount information.

14. A component mounting apparatus according to any one of Claims 4 to 8, wherein after the components are sucked and held by their corresponding suction nozzles of the plurality of component suction devices and before the component recognition is started, the individual nozzle up-and-down devices are driven to move the suction nozzles up and down so that bottom faces of the individual components are aligned.

15. A component suction device for sucking a component (20) which is to be mounted onto a circuit-forming body (2), comprising:

a drive shaft (500) which is up-and-down movable and rotatable about its axis;

a suction nozzle (10A) which is fitted at a lower end of the drive shaft so as to be relatively unturnable and up-and-down relatively immovable and which can suck and hold the component;

a θ-turn driving motor (25A) which is connected to an upper portion of the drive shaft so as to be up-and-down relatively movable and relatively unturnable and which

turns the drive shaft about its axis; and

an up-and-down driver device (26A) which has a first coupling section (501) connected to the drive shaft up-and-down relatively immovably and relatively turnably and which drives up and down the first coupling section to thereby drive the drive shaft up and down.

16. A component suction device according to Claim 15, wherein the drive shaft is provided in a plural number and each of the drive shafts is equipped with the up-and-down driver device and the θ-turn driving motor, and wherein array pitches of the up-and-down driver devices and the θ-turn driving motors are equal to an array pitch of the suction nozzles and further equal to an array pitch of a plurality of component feed sections of a component feed device which feeds the components to be sucked and held by the suction nozzles.

17. A component suction device according to Claim 15 or 16, wherein the up-and-down driver device is a linear motor.

18. A component suction device according to any one of Claims 15 to 17, wherein the θ-turn driving motor is a brushless motor.

19. A component suction device according to any one of Claims 15 to 18, further comprising a suction control valve (580) for controlling suction operation of the nozzle.

20. A component suction device according to Claim 18, wherein the brushless motor comprises:

a rotor which is supported so as to be axially turnable and which is magnetized to a plurality of poles peripherally; and a stator in which a fore end portion of teeth having a coil wound around a tooth winding portion is opposed to an outer periphery of the rotor, so that the rotor is turned along with a rotating magnetic field of the stator, and wherein

the fore end portion of each of the teeth of the stator is shaped into a circular-arc surface extending along the outer periphery of the rotor, and the tooth winding portions are formed parallel to one another.

21. A component suction device according to Claim 20, wherein in the brushless motor, the stator is so formed that the circular-arc surfaces of the fore end portions of the teeth confronting the outer periphery of the rotor have a symmetrical slot pitch.

22. A component suction device according to Claim 20 or 21, wherein in the brushless motor, the stator has a thickness along the axis of the rotor and has such a flat shape along an end face of the rotor that a first length formed by connecting 0° and 180° to each other about the axis is shorter than a second length formed by connecting 90° and 270° to each other.

23. A component suction device according to Claim 22, wherein in the brushless motor,

the flat-type stator is formed of first, second stator blocks which contact each other at a boundary of connection between the 0° and 180° about the axis.

24. A component suction device according to Claim 23, wherein in the brushless motor,

each stator block of the first stator block and the second stator is composed of a plurality of tooth blocks which are joined together so that a magnetic path is formed by base end portions of their tooth winding portions.

25. A component suction device according to Claim 24, wherein in the brushless motor,

the flat-type stator is formed of a single stator block.

26. A component suction device according to Claim 24, wherein in the brushless motor,

the flat-type stator has

grooves which serve as the tooth winding portion and which are formed thicknesswise in a side surface of the stator crossing a direction of the first length, where

an outermost peripheral surface of the coil wound on the grooves is positioned so as to be flush with the side surface or inner than the side surface.

27. A component suction device according to Claim 17,

wherein the linear motor includes:

a plurality of frame coils provided inside a cylindrical outer yoke on a stationary side;

an inner yoke having a plurality of teeth in which a magnetic communicating portion is formed at at least one end so as to pass through the frame coils; and

magnets provided on both surfaces of each tooth so that teeth in which faces opposed to the frame coils have a single polarity adjoin to each other in polarity different from each other, where

a magnetic flux radiated from a specific magnet out of the magnets flows to an adjacent tooth via the outer yoke, passing through the magnetic communicating portion, and flowing through the tooth on which the specific magnet is provided, and thus flowing back to the specific magnet, and wherein

with an electric current supplied to the frame coil, a movable side composed of the magnets and the inner yoke moves longitudinally of the teeth.

28. A component suction device according to Claim 27, wherein in the linear motor, the inner yoke is U-shaped.

29. A component suction device according to Claim 27, wherein in the linear motor, the frame coil has an opening face having such a rectangular shape that a length of its side line opposite to the magnet is longer than a length of

its span section.

30. A component suction device according to Claim 28, wherein the linear motor includes:

an inner yoke having a plurality of teeth in which a magnetic communicating portion is formed at at least one end thereof;

an outer yoke which externally surrounds the plurality of tooth;

magnets provided opposite to both faces of the teeth inside the outer yoke so that their faces of the magnets opposed to the teeth are of a single pole and the faces opposed to their respective adjoining teeth are different in polarity from each other;

coils wound on the individual teeth of the inner yoke;

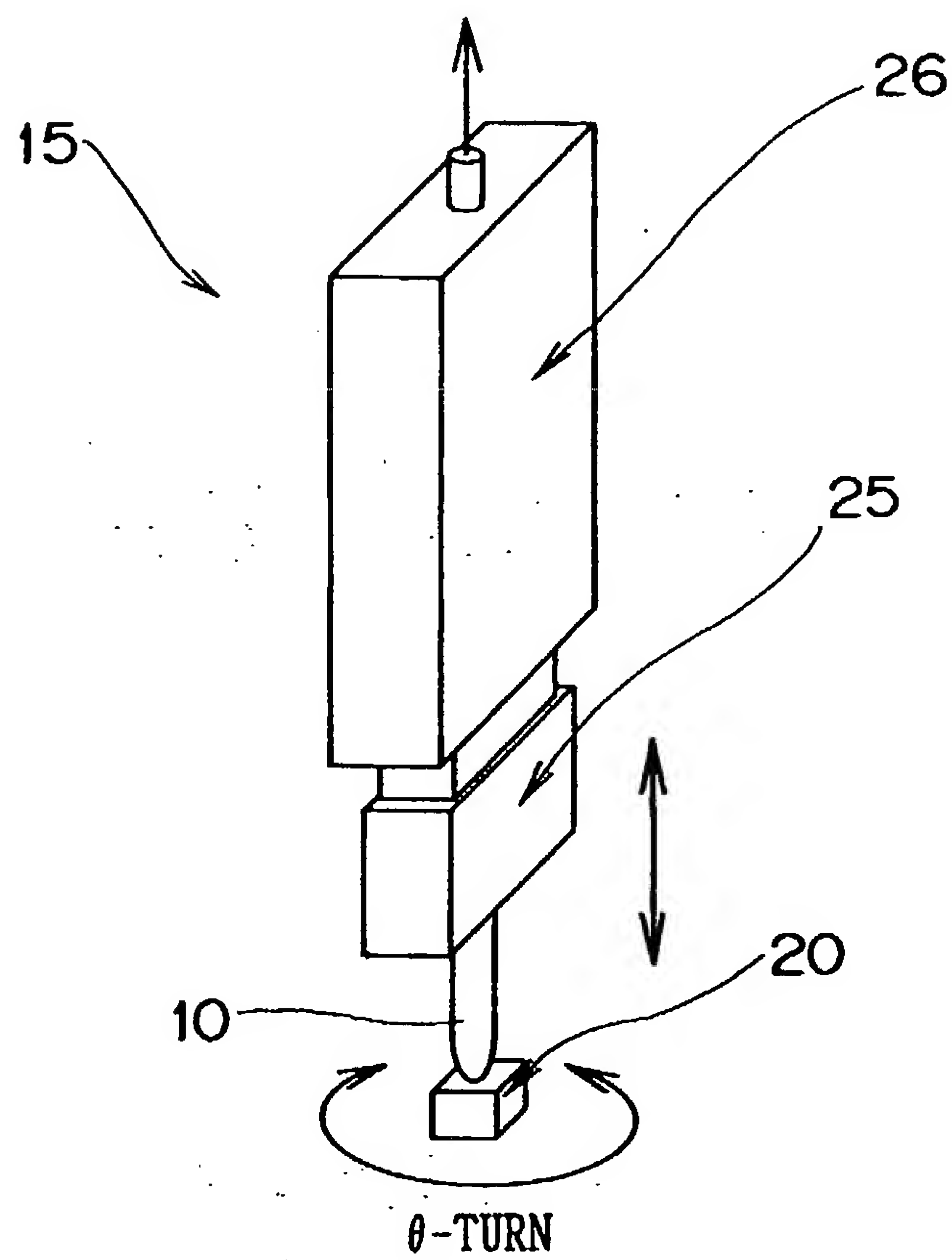
a magnetic flux radiated from a specific magnet out of the magnets flows to an adjacent tooth via the outer yoke, passing through the magnetic communicating portion, and flowing through the tooth opposing the specific magnet, and thus flowing back to the specific magnet, and wherein

with an electric current supplied to the coil, a movable side composed of the magnets and the outer yoke moves in a longitudinal direction of the teeth.

31. A component suction device according to Claim 30, wherein in the linear motor, the teeth each have such a

rectangular shape that a length of its side line opposite to the magnet is longer than a length of a connection side connecting the opposite side lines to each other.

Fig. 1



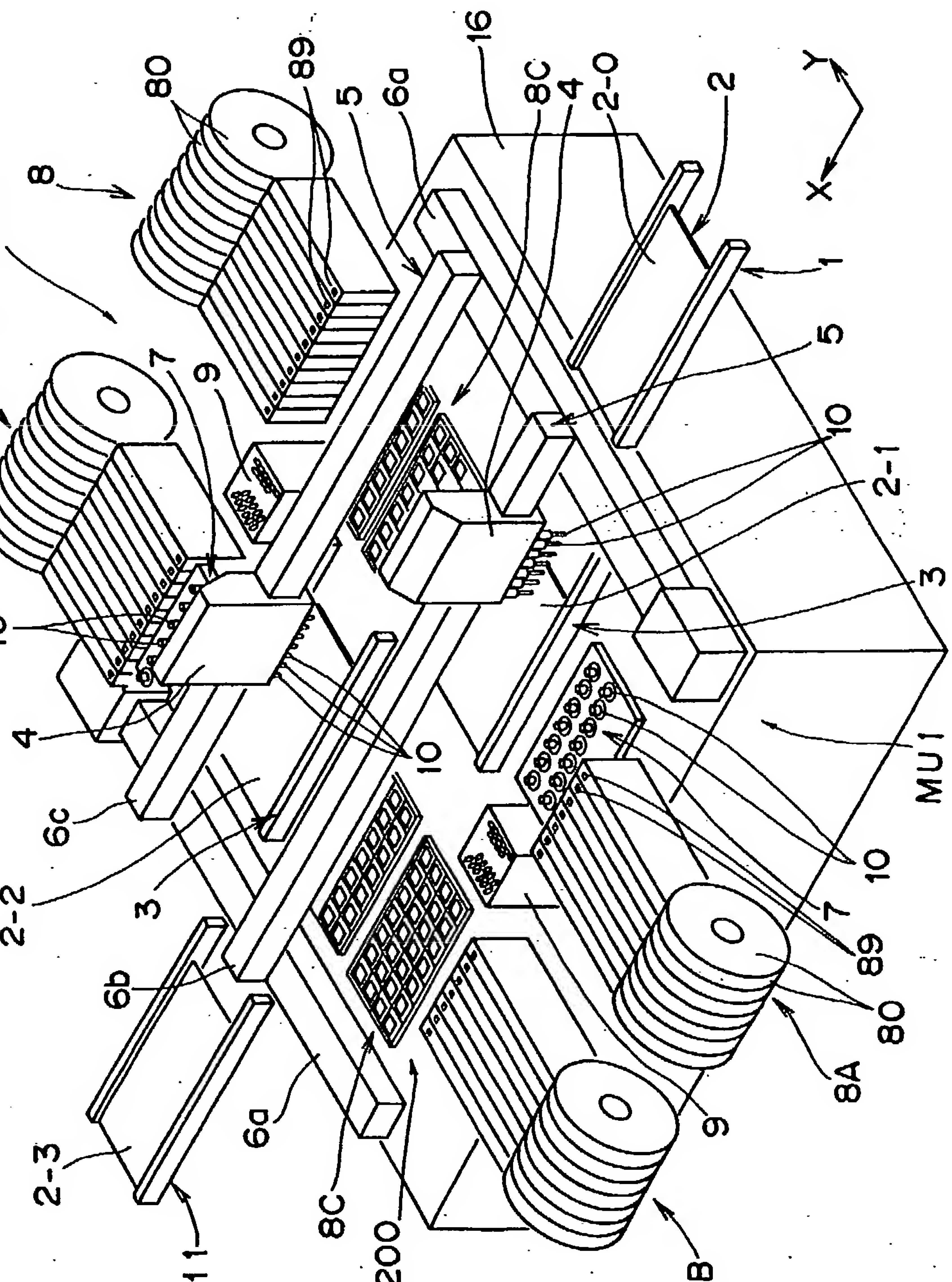

MU2
MU1
8
8
80
89
16
8C
4
2-0
2
5
6a
Y
X
1
7
9
10
2-1
3
4
6c
2-2
6b
2-3
11
6a
8C
200
8B
8A
80
89
7
10
9

Fig. 2

Fig. 3

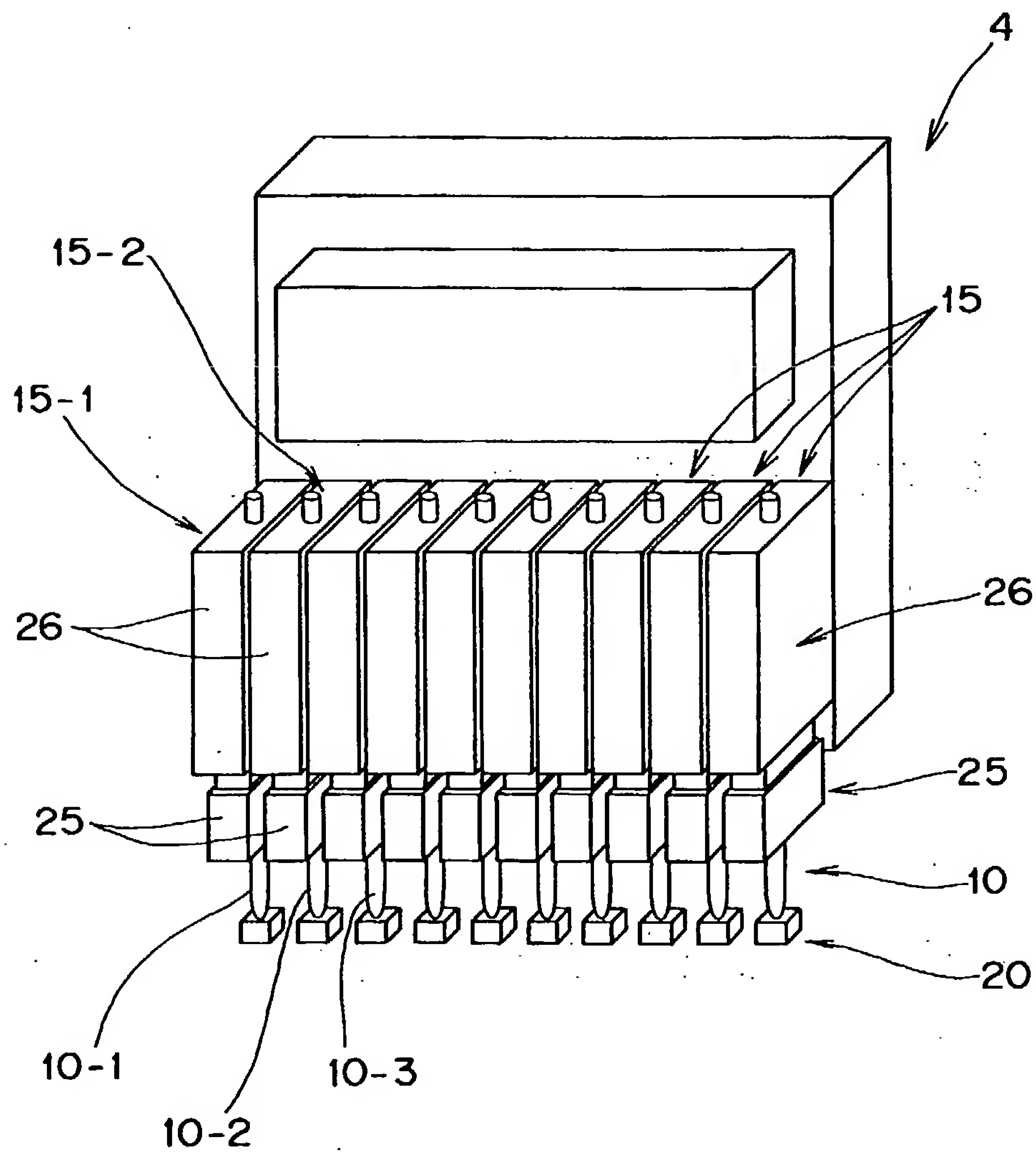


Fig.4

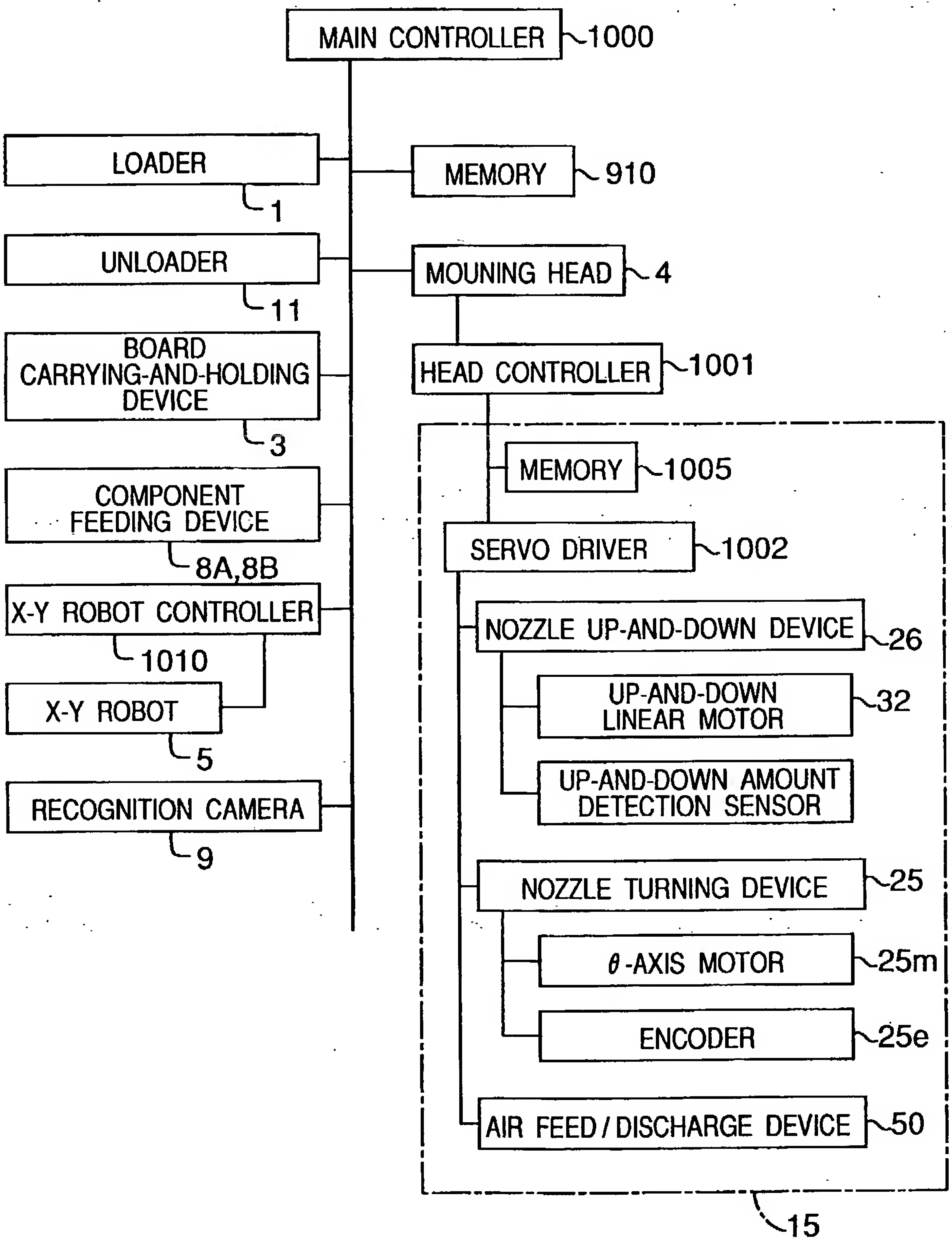

MAIN CONTROLLER
1000
LOADER
1
MEMORY
910
UNLOADER
11
MOUNING HEAD
4
BOARD CARRYING-AND-HOLDING DEVICE
3
HEAD CONTROLLER
1001
MEMORY
1005
COMPONENT FEEDING DEVICE
8A,8B
SERVO DRIVER
1002
X-Y ROBOT CONTROLLER
1010
NOZZLE UP-AND-DOWN DEVICE
26
X-Y ROBOT
5
UP-AND-DOWN LINEAR MOTOR
32
RECOGNITION CAMERA
9
UP-AND-DOWN AMOUNT DETECTION SENSOR
NOZZLE TURNING DEVICE
25
θ-AXIS MOTOR
25m
ENCODER
25e
AIR FEED / DISCHARGE DEVICE
50
15

Fig.5A

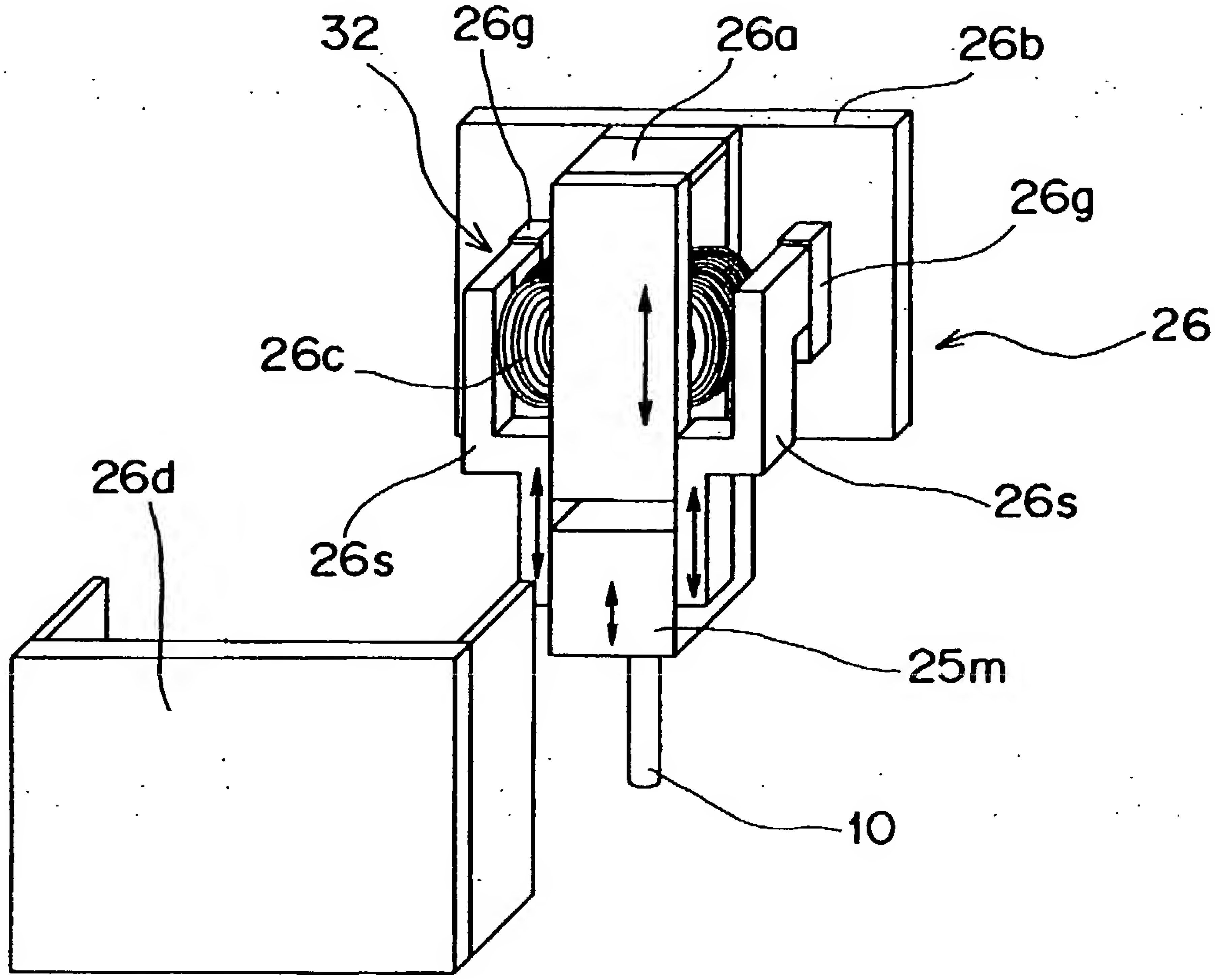

32
26g
26a
26b
26g
26
26c
26d
26s
26s
25m
10

Fig.5B

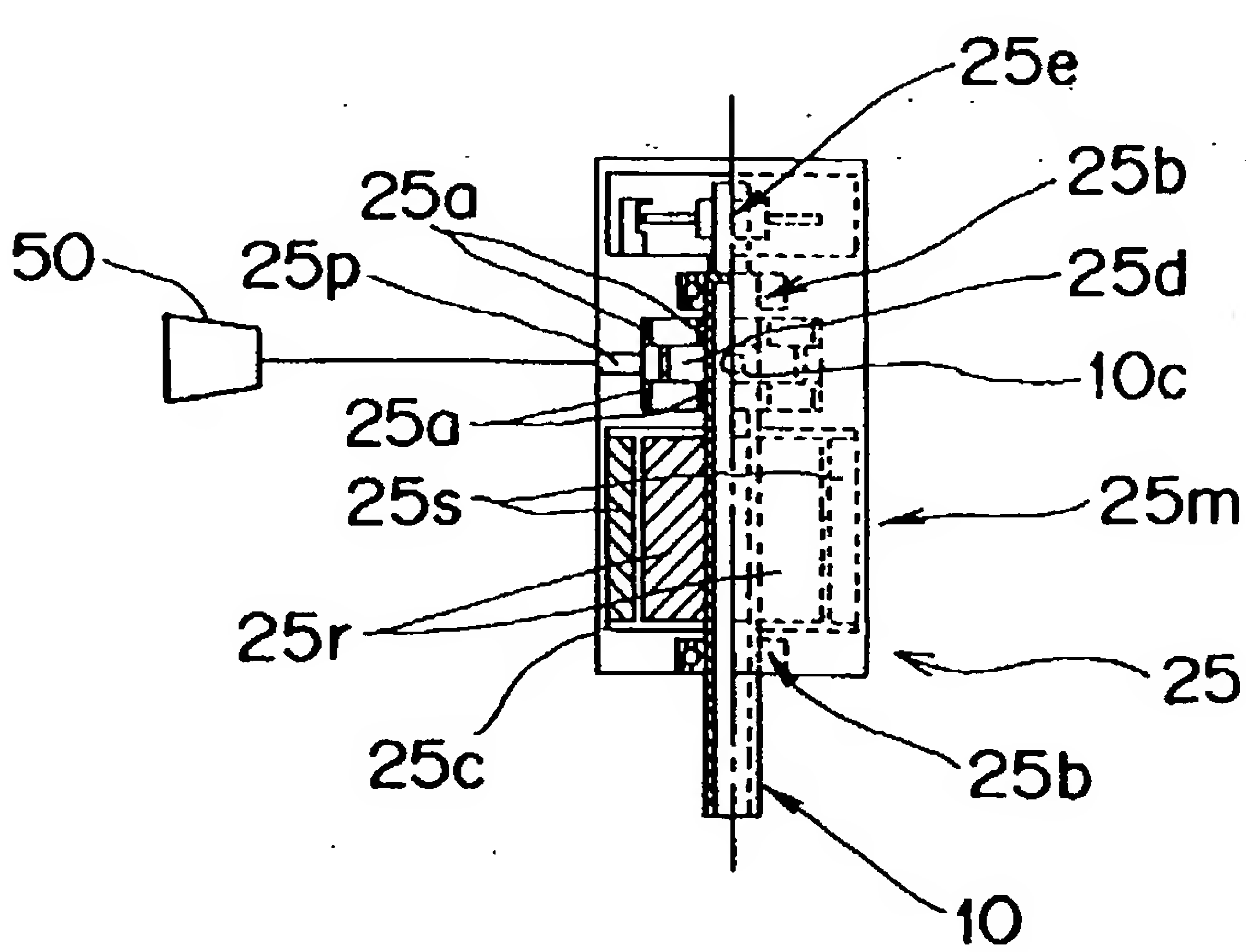

25e
25b
25a
50
25p
25d
10c
25a
25s
25m
25r
25
25c
25b
10

Fig.6

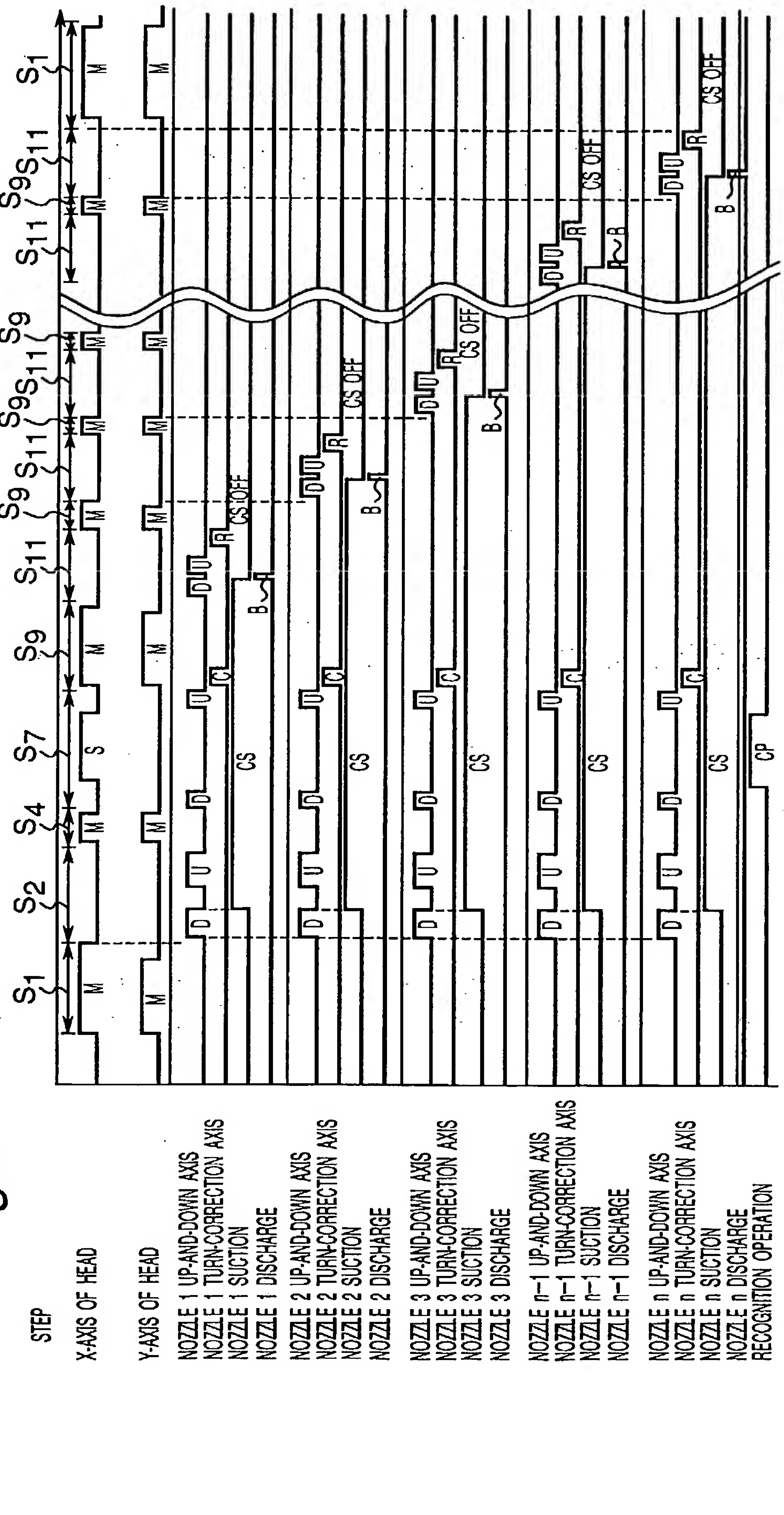
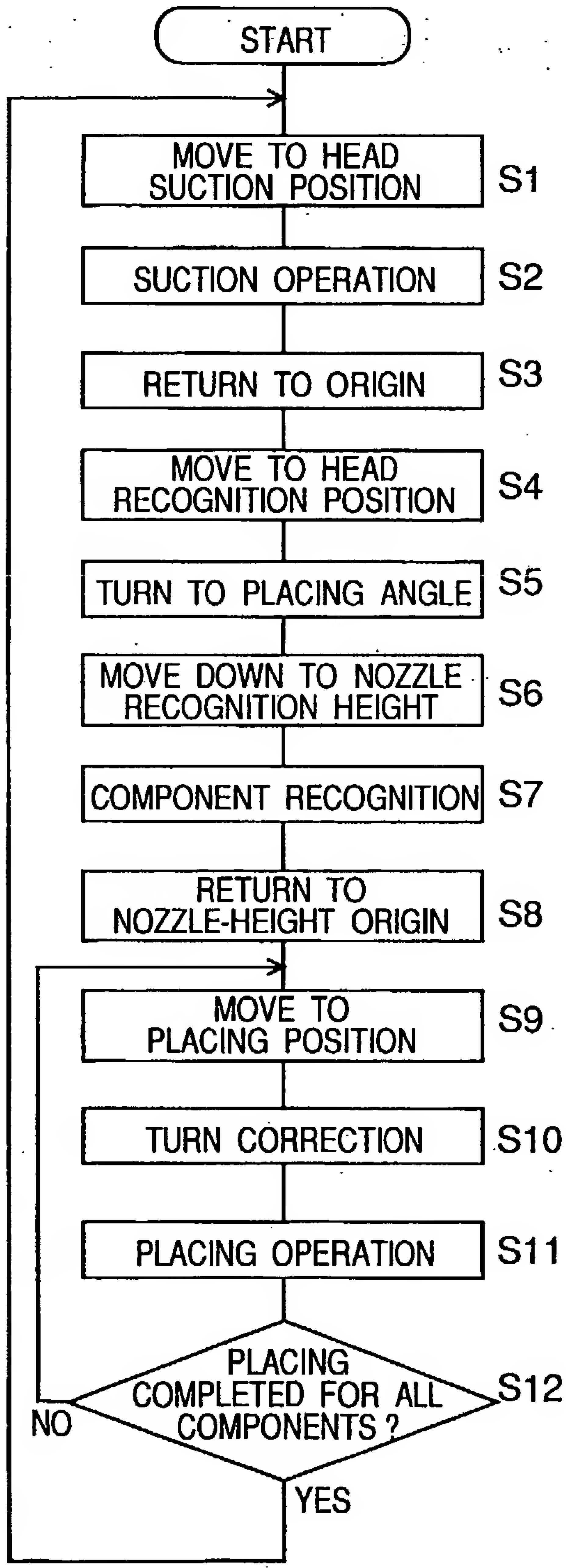

STEP
X-AXIS OF HEAD
Y-AXIS OF HEAD
NOZZLE 1 UP-AND-DOWN AXIS
NOZZLE 1 TURN-CORRECTION AXIS
NOZZLE 1 SUCTION
NOZZLE 1 DISCHARGE
NOZZLE 2 UP-AND-DOWN AXIS
NOZZLE 2 TURN-CORRECTION AXIS
NOZZLE 2 SUCTION
NOZZLE 2 DISCHARGE
NOZZLE 3 UP-AND-DOWN AXIS
NOZZLE 3 TURN-CORRECTION AXIS
NOZZLE 3 SUCTION
NOZZLE 3 DISCHARGE
NOZZLE n−1 UP-AND-DOWN AXIS
NOZZLE n−1 TURN-CORRECTION AXIS
NOZZLE n−1 SUCTION
NOZZLE n−1 DISCHARGE
NOZZLE n UP-AND-DOWN AXIS
NOZZLE n TURN-CORRECTION AXIS
NOZZLE n SUCTION
NOZZLE n DISCHARGE
RECOGNITION OPERATION
S1 S2 S4 S7 S9 S11 S9 S11 S9 S11 S9 S9 S11 S9 S11 S1
M D U C S R B CS CS OFF CP

Fig.7


START
MOVE TO HEAD SUCTION POSITION
S1
SUCTION OPERATION
S2
RETURN TO ORIGIN
S3
MOVE TO HEAD RECOGNITION POSITION
S4
TURN TO PLACING ANGLE
S5
MOVE DOWN TO NOZZLE RECOGNITION HEIGHT
S6
COMPONENT RECOGNITION
S7
RETURN TO NOZZLE-HEIGHT ORIGIN
S8
MOVE TO PLACING POSITION
S9
TURN CORRECTION
S10
PLACING OPERATION
S11
PLACING COMPLETED FOR ALL COMPONENTS ?
S12
NO
YES

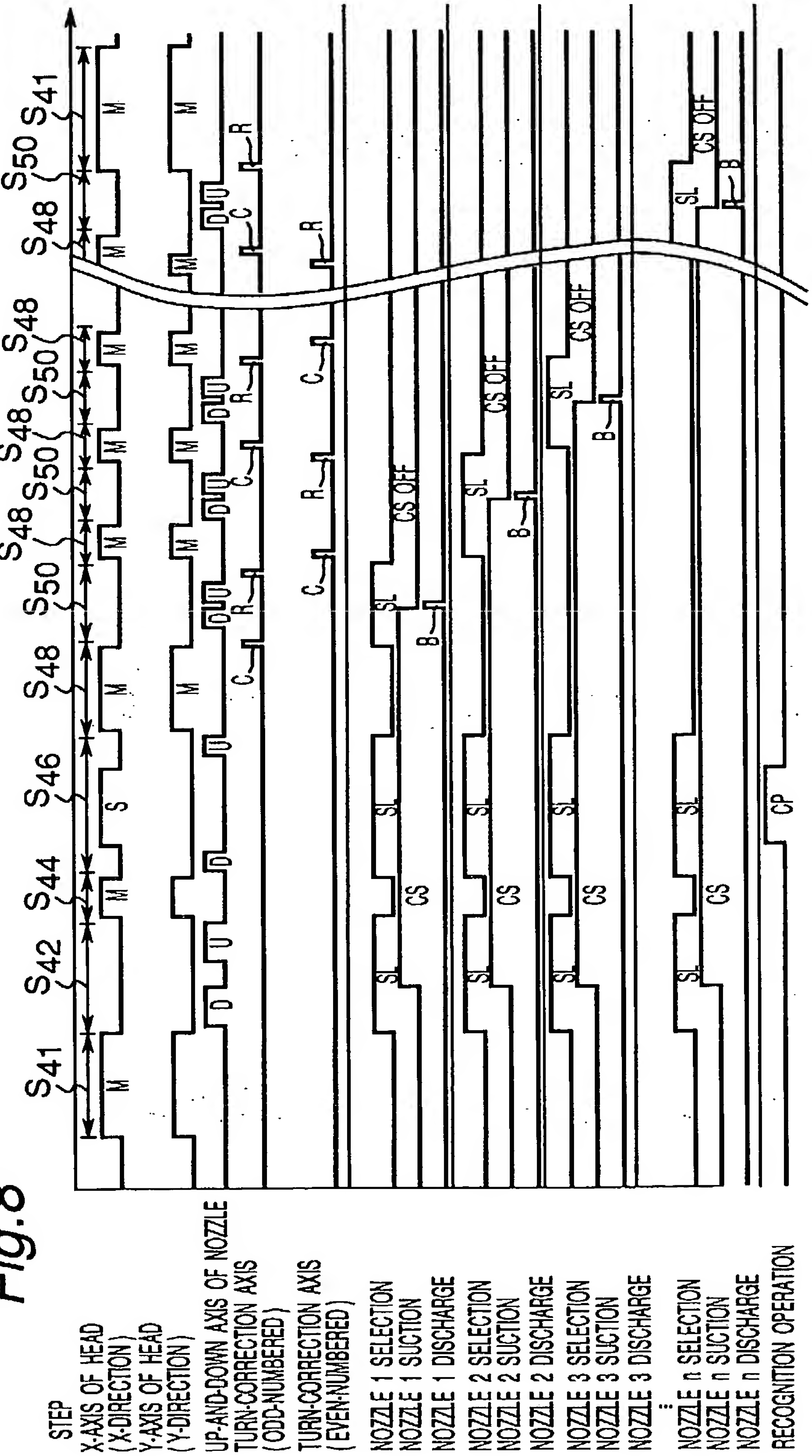

STEP
X-AXIS OF HEAD (X-DIRECTION)
Y-AXIS OF HEAD (Y-DIRECTION)
UP-AND-DOWN AXIS OF NOZZLE
TURN-CORRECTION AXIS (ODD-NUMBERED)
TURN-CORRECTION AXIS (EVEN-NUMBERED)
NOZZLE 1 SELECTION
NOZZLE 1 SUCTION
NOZZLE 1 DISCHARGE
NOZZLE 2 SELECTION
NOZZLE 2 SUCTION
NOZZLE 2 DISCHARGE
NOZZLE 3 SELECTION
NOZZLE 3 SUCTION
NOZZLE 3 DISCHARGE
NOZZLE n SELECTION
NOZZLE n SUCTION
NOZZLE n DISCHARGE
RECOGNITION OPERATION
S41
S42
S44
S46
S48
S50
M
D
U
S
C
R
SL
CS
CS OFF
B
CP

Fig.8

Fig.9

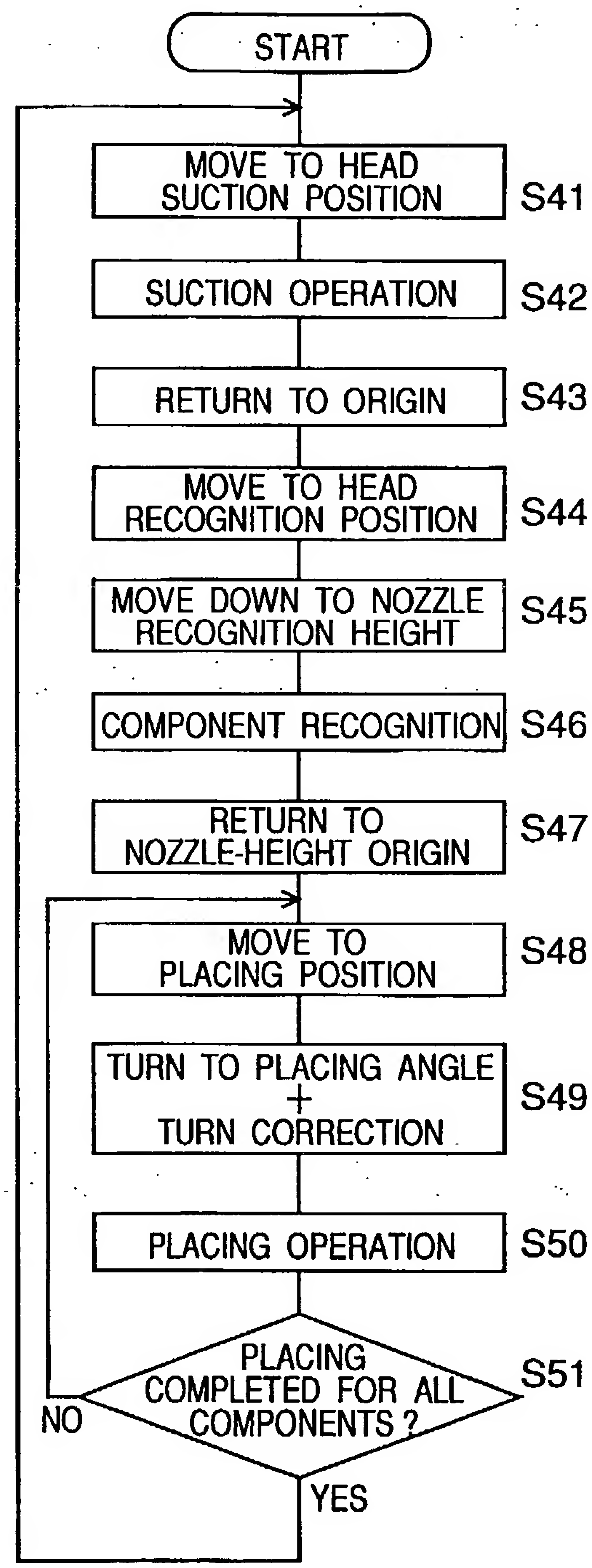
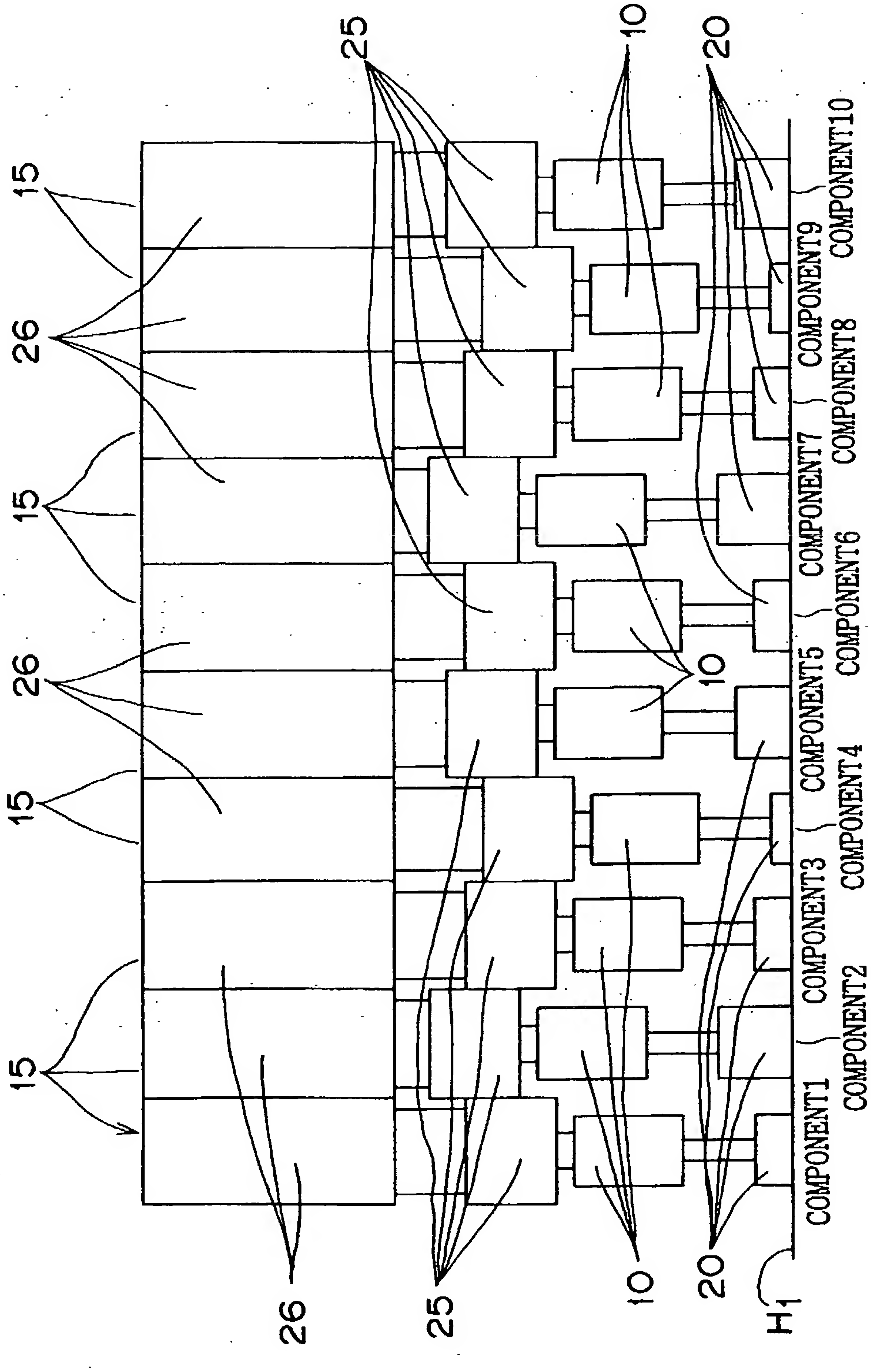

START
MOVE TO HEAD SUCTION POSITION
S41
SUCTION OPERATION
S42
RETURN TO ORIGIN
S43
MOVE TO HEAD RECOGNITION POSITION
S44
MOVE DOWN TO NOZZLE RECOGNITION HEIGHT
S45
COMPONENT RECOGNITION
S46
RETURN TO NOZZLE-HEIGHT ORIGIN
S47
MOVE TO PLACING POSITION
S48
TURN TO PLACING ANGLE + TURN CORRECTION
S49
PLACING OPERATION
S50
PLACING COMPLETED FOR ALL COMPONENTS ?
S51
NO
YES

Fig.10


15
26
15
26
15
15
25
10
20
10
26
25
10
20
H_1
COMPONENT1
COMPONENT2
COMPONENT3
COMPONENT4
COMPONENT5
COMPONENT6
COMPONENT7
COMPONENT8
COMPONENT9
COMPONENT10

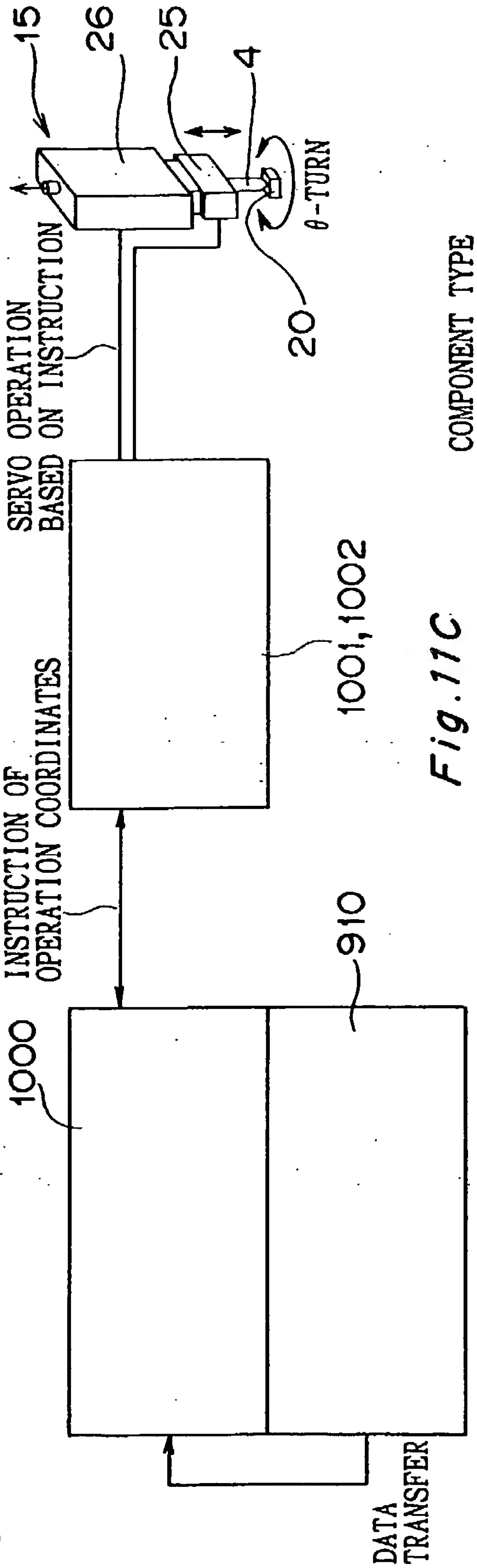


Fig. 11A

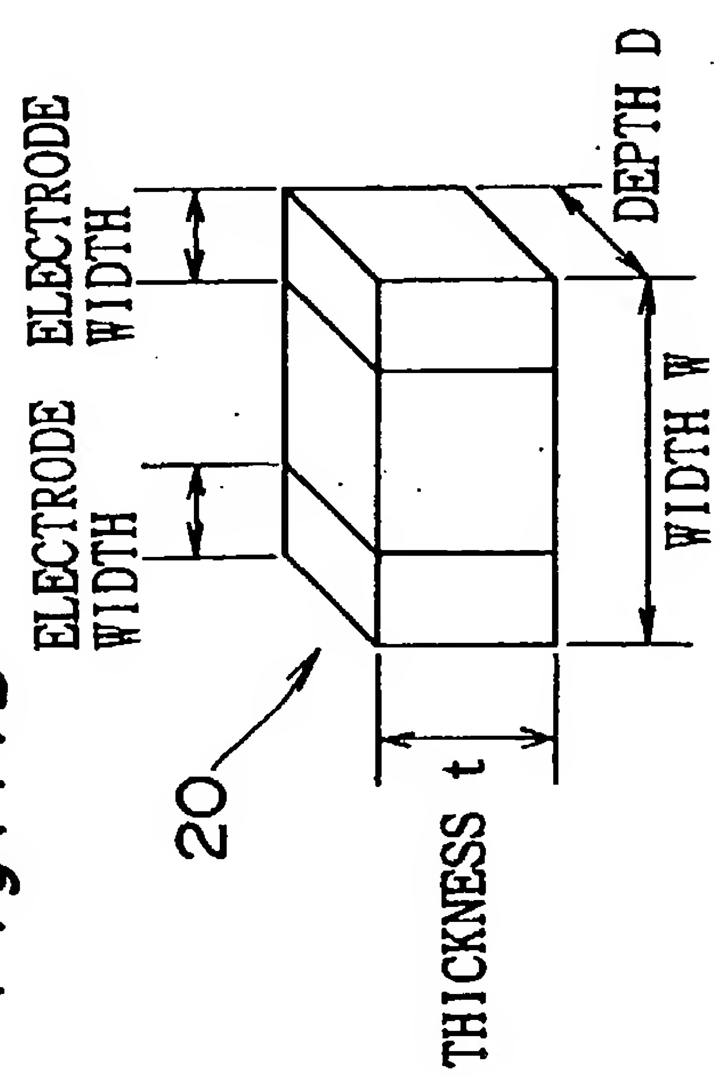


Fig. 11B

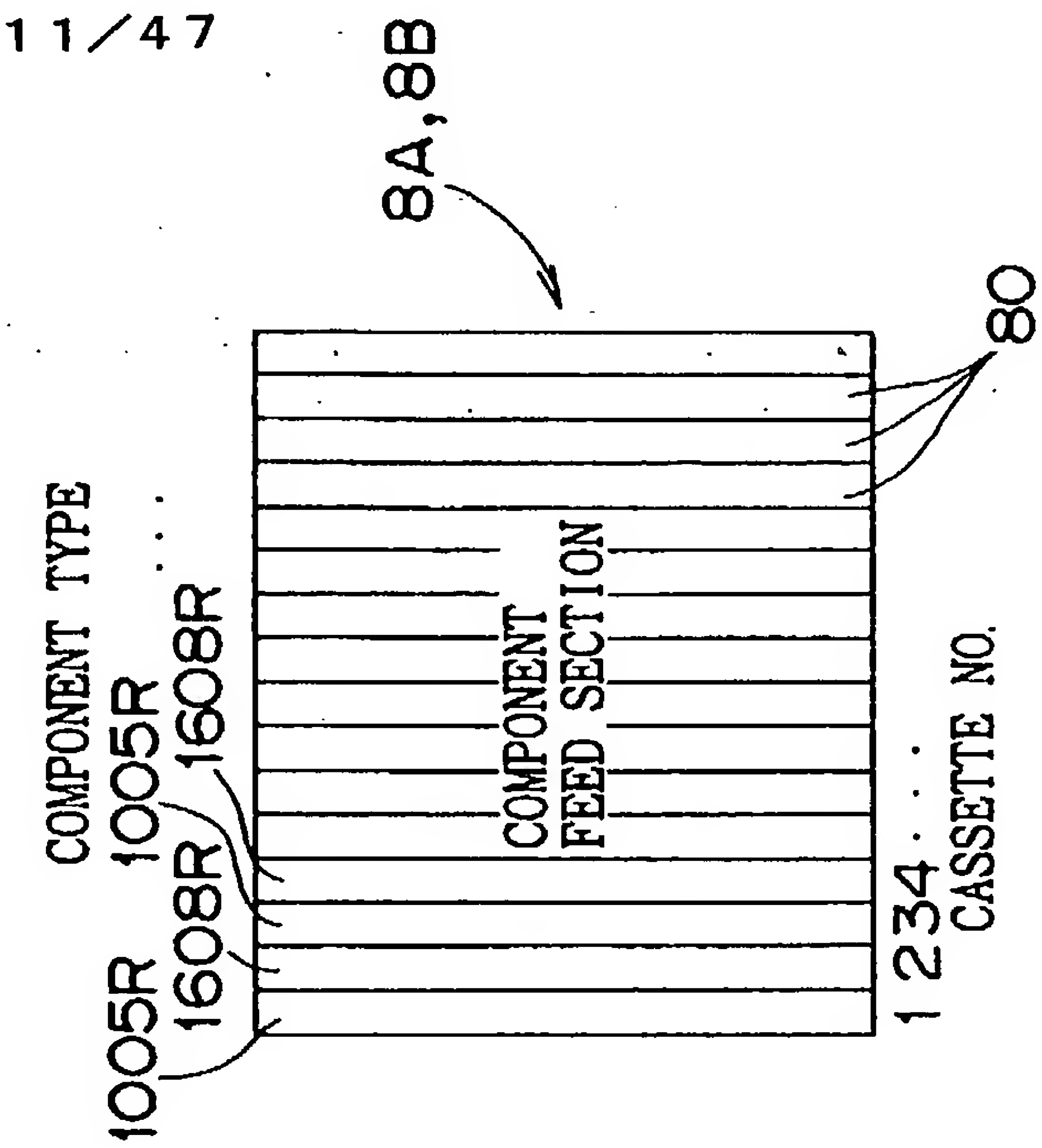
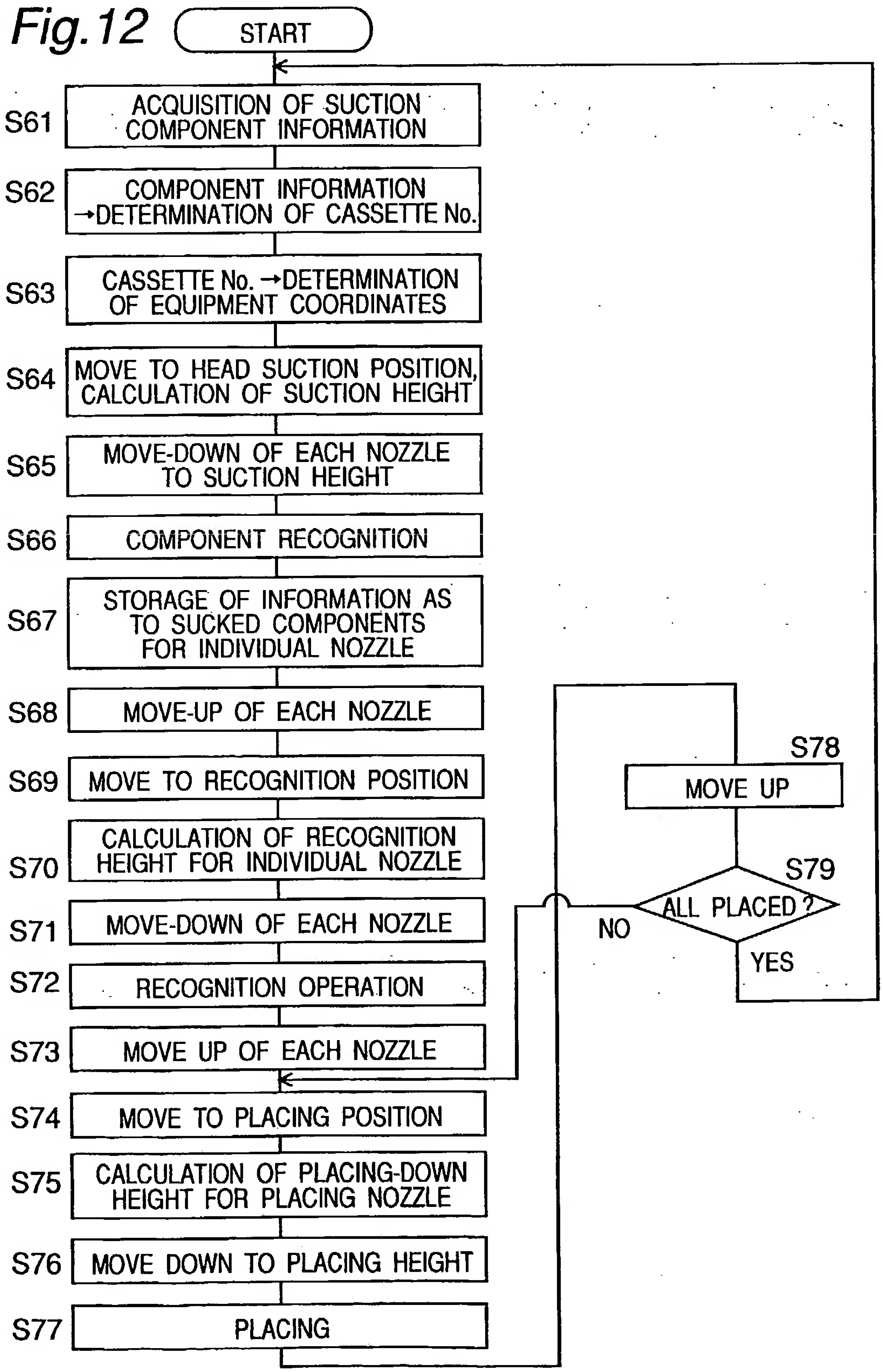


Fig. 11C

Fig.12


START
S61
ACQUISITION OF SUCTION COMPONENT INFORMATION
S62
COMPONENT INFORMATION →DETERMINATION OF CASSETTE No.
S63
CASSETTE No. →DETERMINATION OF EQUIPMENT COORDINATES
S64
MOVE TO HEAD SUCTION POSITION, CALCULATION OF SUCTION HEIGHT
S65
MOVE-DOWN OF EACH NOZZLE TO SUCTION HEIGHT
S66
COMPONENT RECOGNITION
S67
STORAGE OF INFORMATION AS TO SUCKED COMPONENTS FOR INDIVIDUAL NOZZLE
S68
MOVE-UP OF EACH NOZZLE
S69
MOVE TO RECOGNITION POSITION
S70
CALCULATION OF RECOGNITION HEIGHT FOR INDIVIDUAL NOZZLE
S71
MOVE-DOWN OF EACH NOZZLE
S72
RECOGNITION OPERATION
S73
MOVE UP OF EACH NOZZLE
S74
MOVE TO PLACING POSITION
S75
CALCULATION OF PLACING-DOWN HEIGHT FOR PLACING NOZZLE
S76
MOVE DOWN TO PLACING HEIGHT
S77
PLACING
S78
MOVE UP
S79
ALL PLACED?
NO
YES

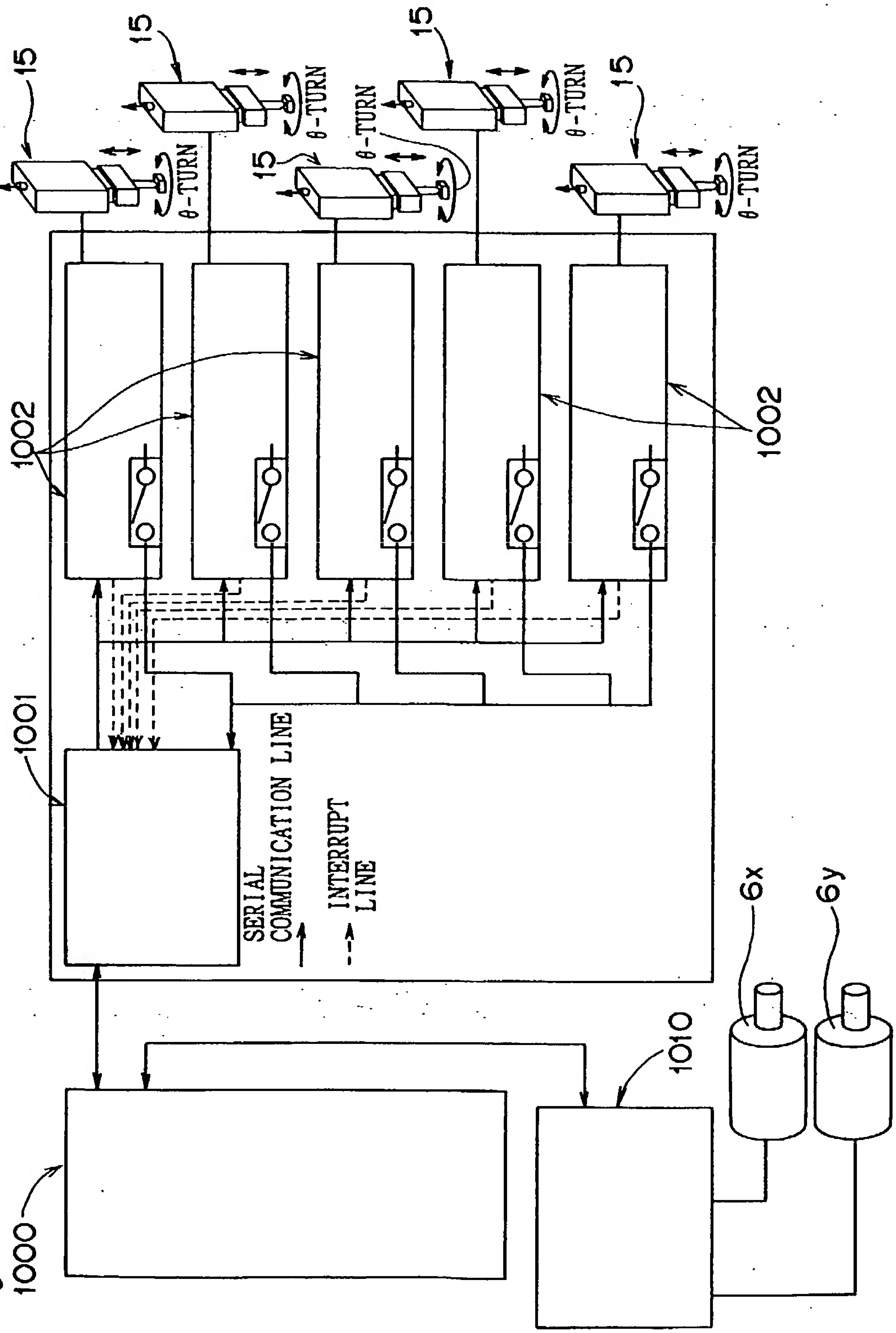

15
θ-TURN
1002
1001
SERIAL COMMUNICATION LINE
INTERRUPT LINE
1000
1010
6x
6y

Fig.13

Fig.14

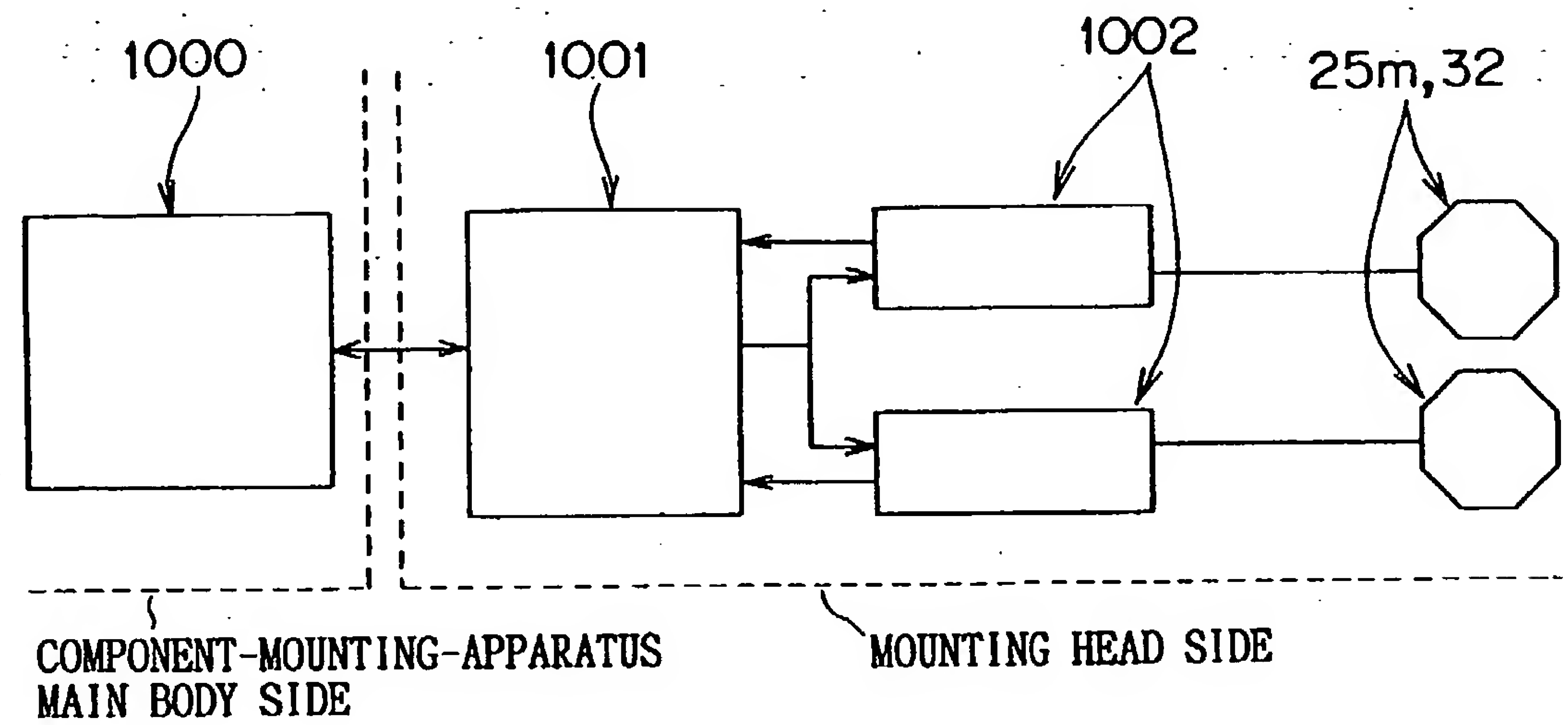

1000
1001
1002
25m,32
COMPONENT-MOUNTING-APPARATUS MAIN BODY SIDE
MOUNTING HEAD SIDE

Fig.15

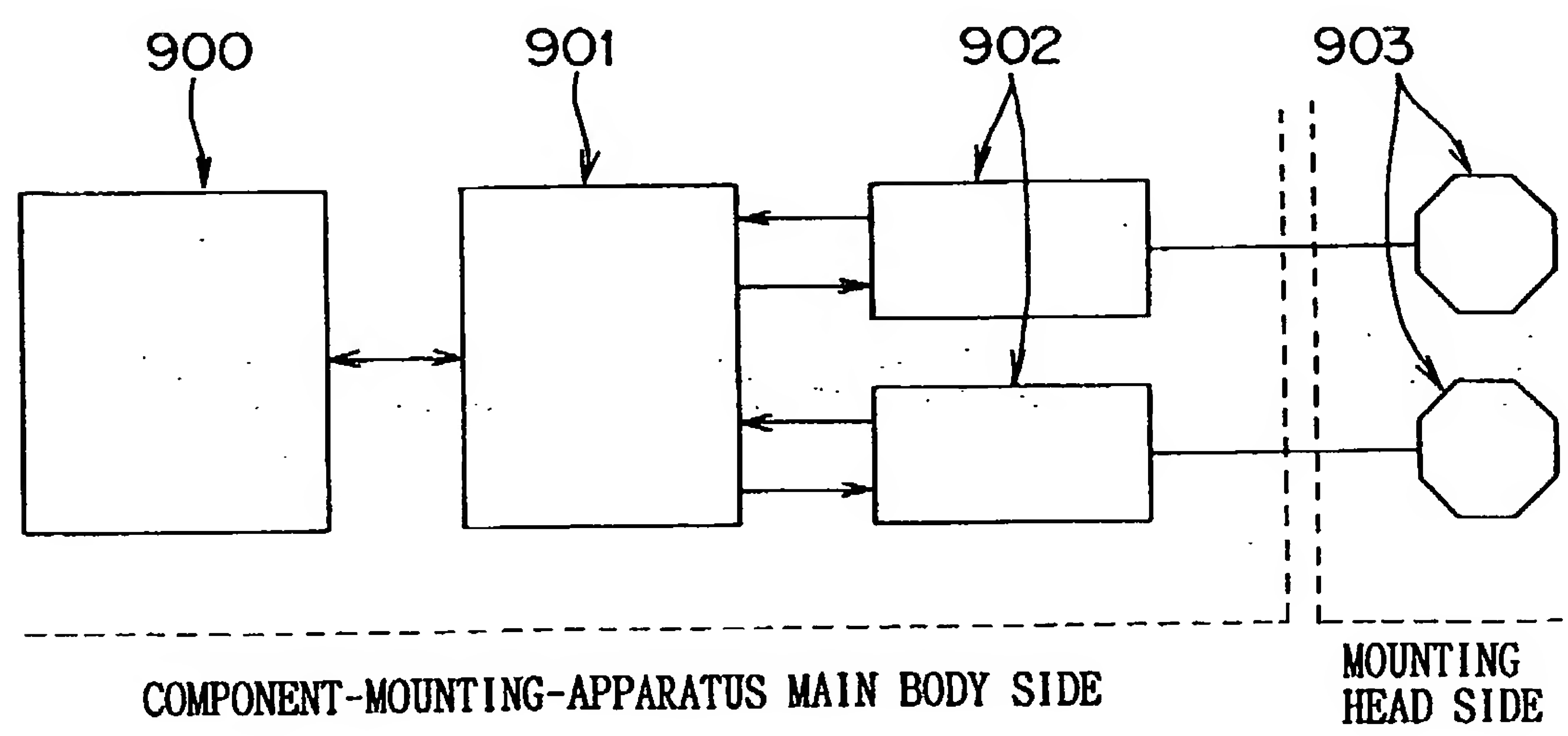

900
901
902
903
COMPONENT-MOUNTING-APPARATUS MAIN BODY SIDE
MOUNTING HEAD SIDE

Fig. 16

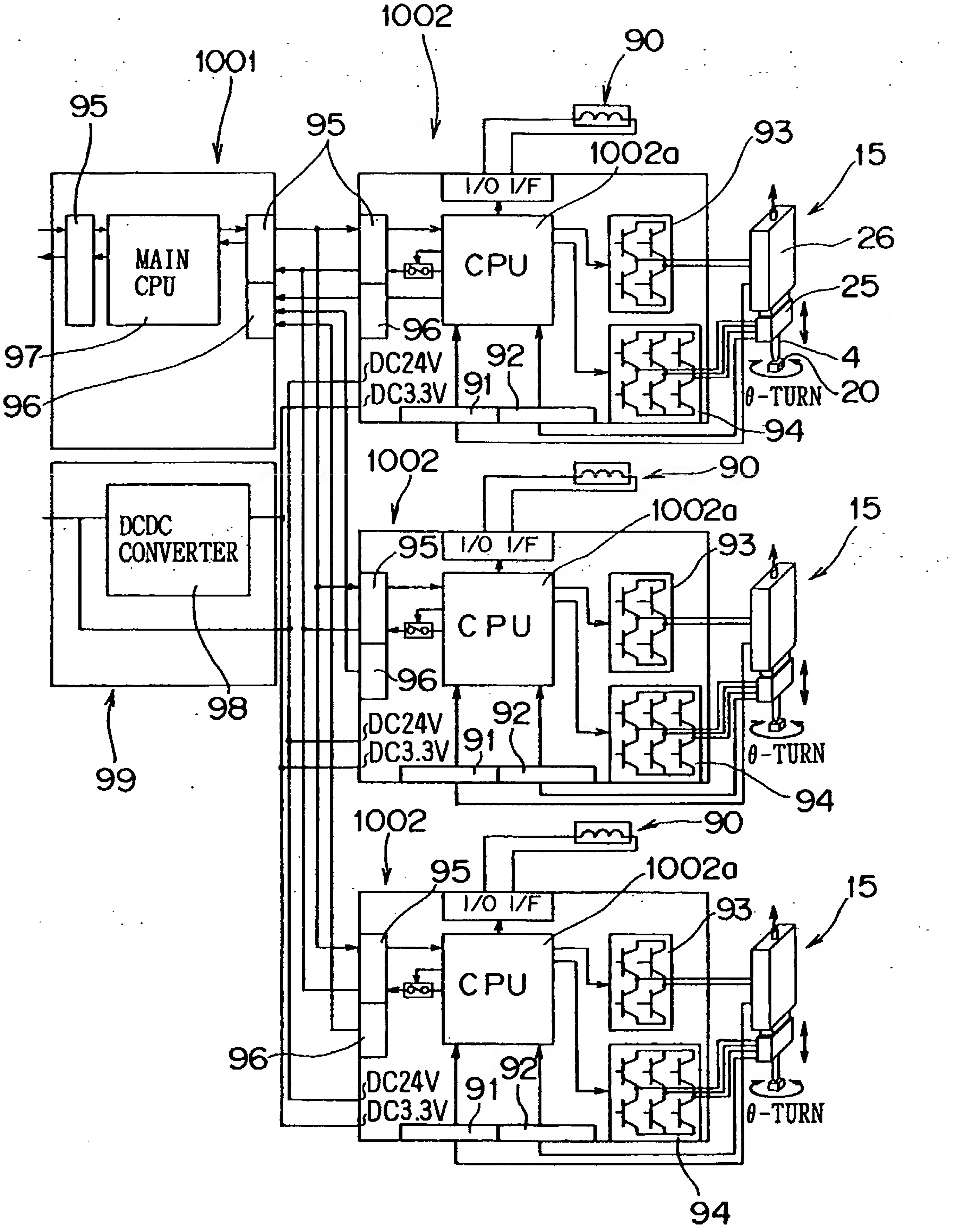

1002
90
1001
95
95
93
1002a
15
I/O I/F
MAIN CPU
CPU
26
25
96
97
DC24V
92
4
DC3.3V
91
θ-TURN
20
96
94
1002
90
1002a
15
DCDC CONVERTER
95
I/O I/F
93
CPU
96
98
DC24V
92
99
DC3.3V
91
θ-TURN
94
1002
90
95
1002a
15
I/O I/F
93
CPU
96
DC24V
91
92
DC3.3V
θ-TURN
94

Fig.17A

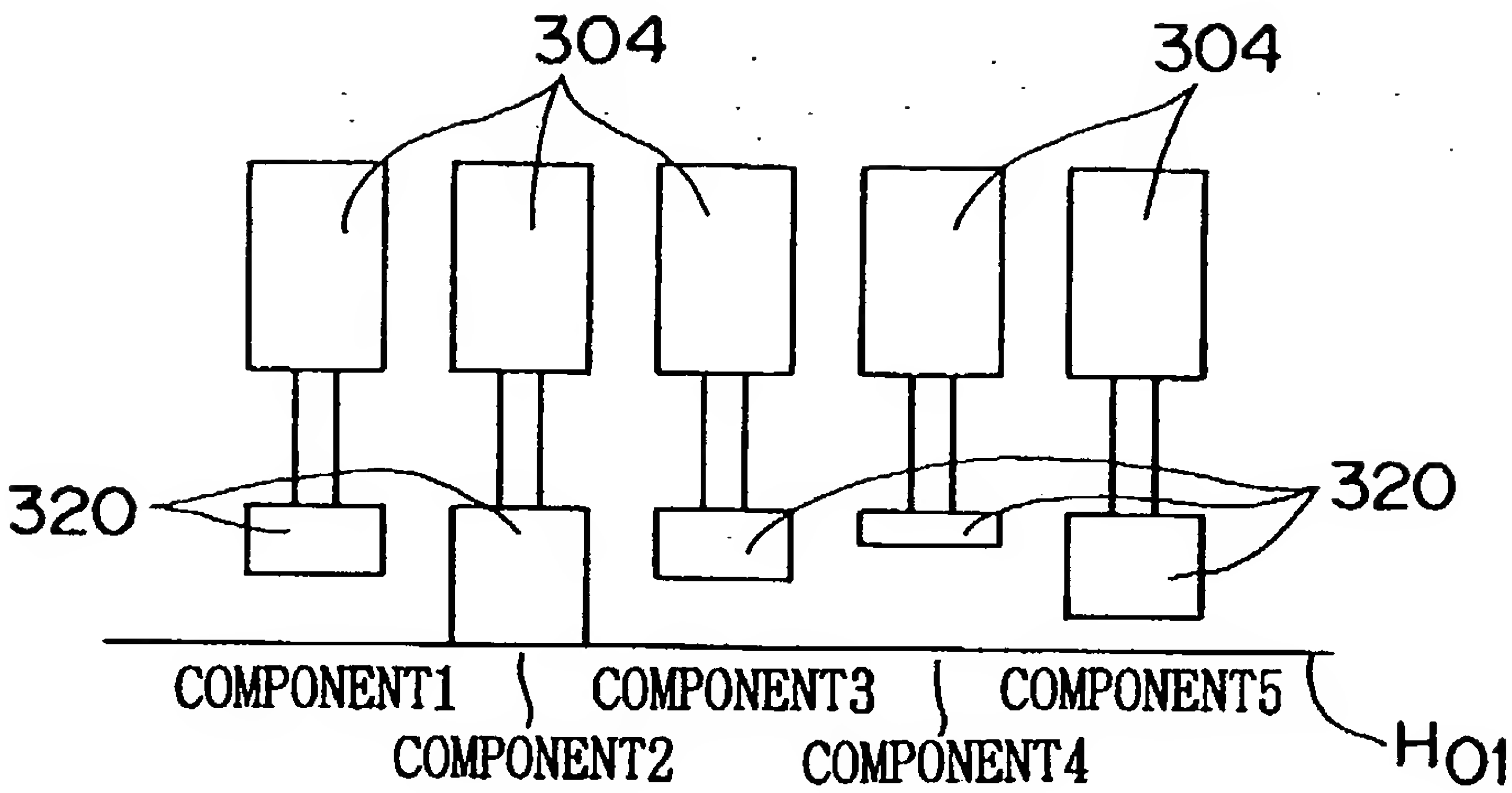
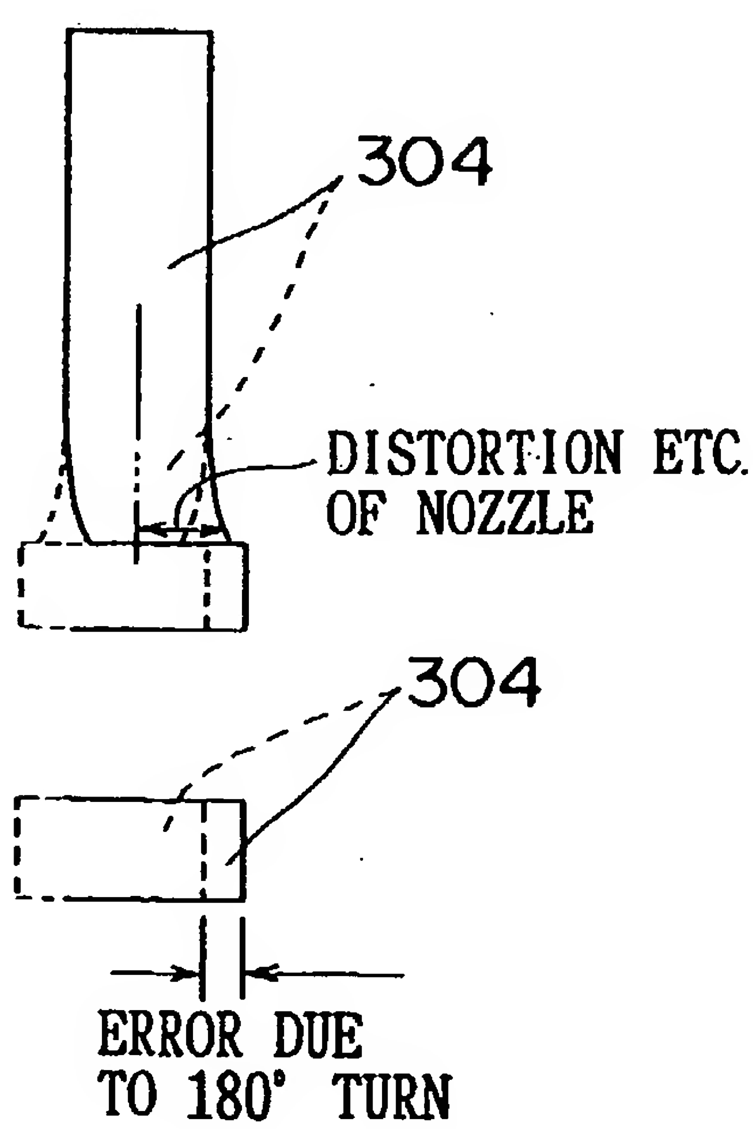


Fig.17B



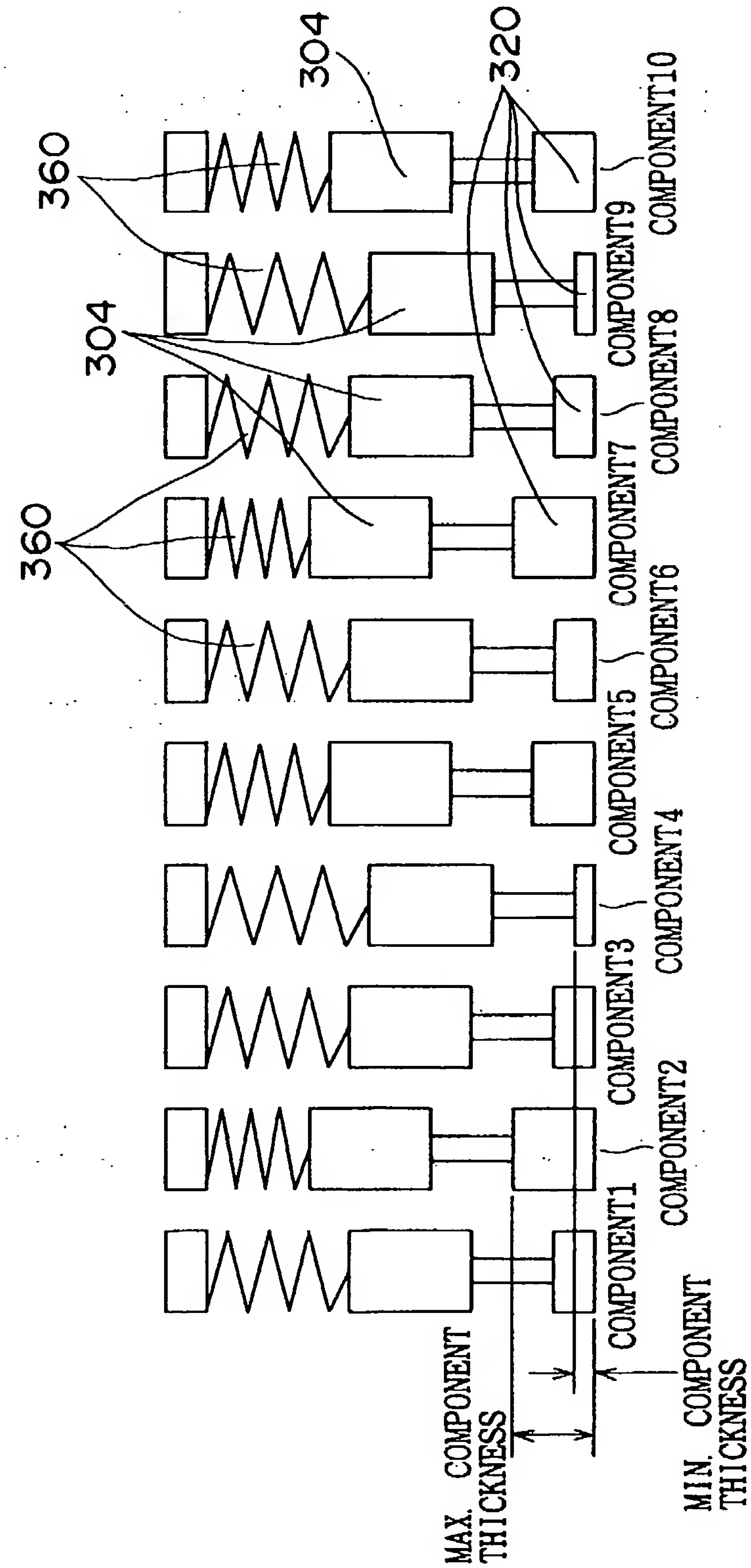
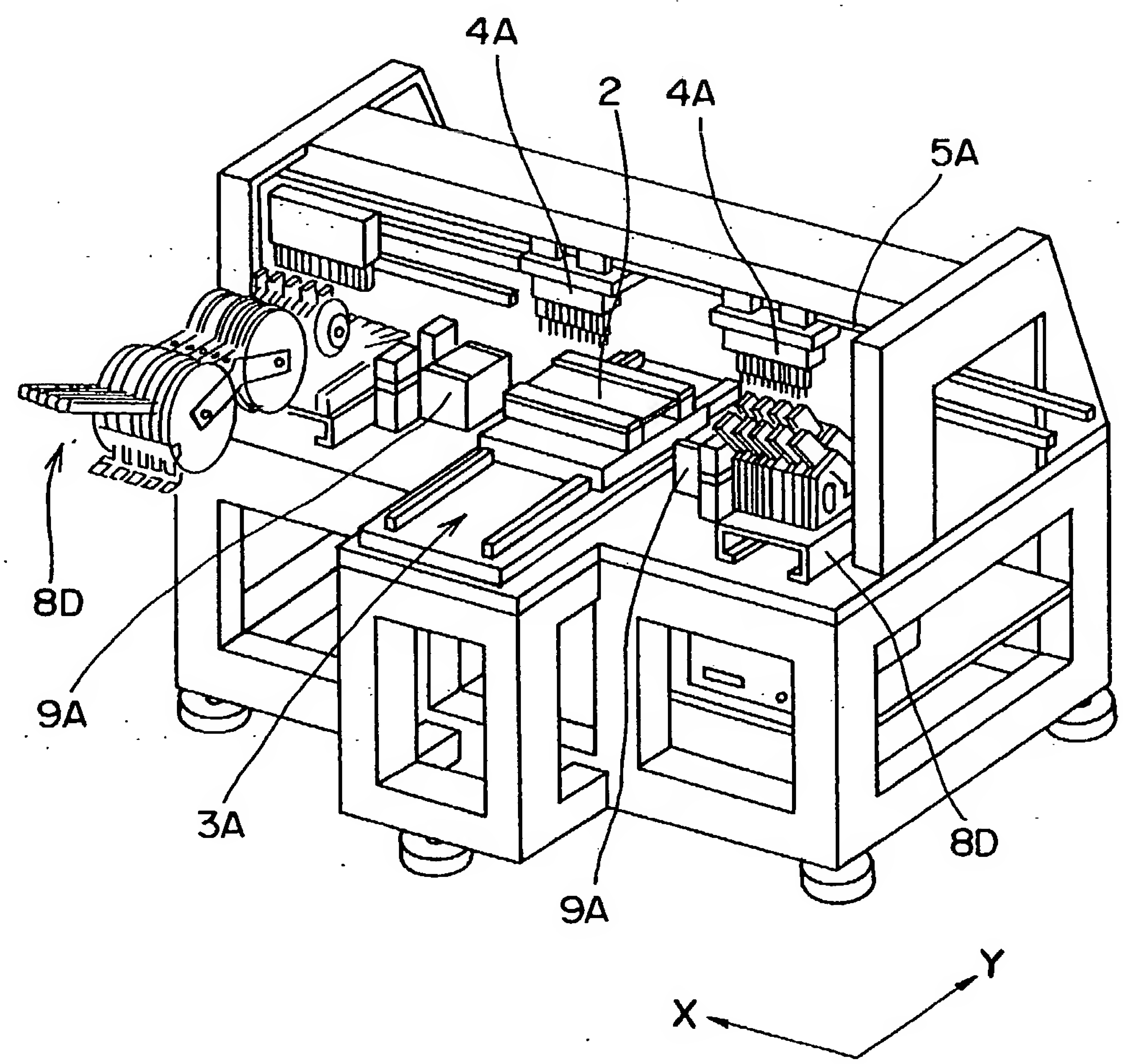

304
320
360
304
360
COMPONENT10
COMPONENT9
COMPONENT8
COMPONENT7
COMPONENT6
COMPONENT5
COMPONENT4
COMPONENT3
COMPONENT2
COMPONENT1
MAX. COMPONENT THICKNESS
MIN. COMPONENT THICKNESS

Fig.18

Fig. 19



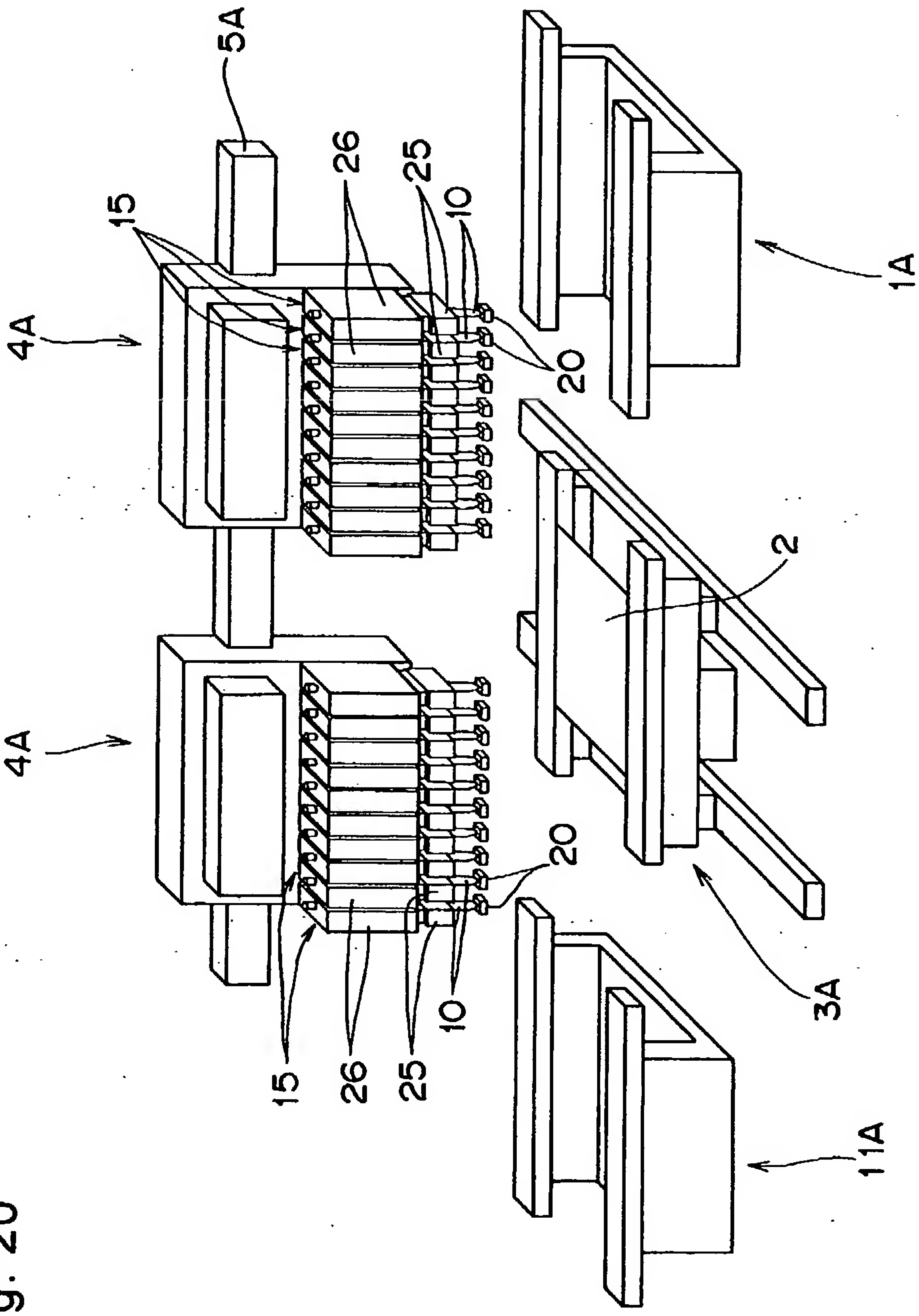


Fig. 20

Fig.21

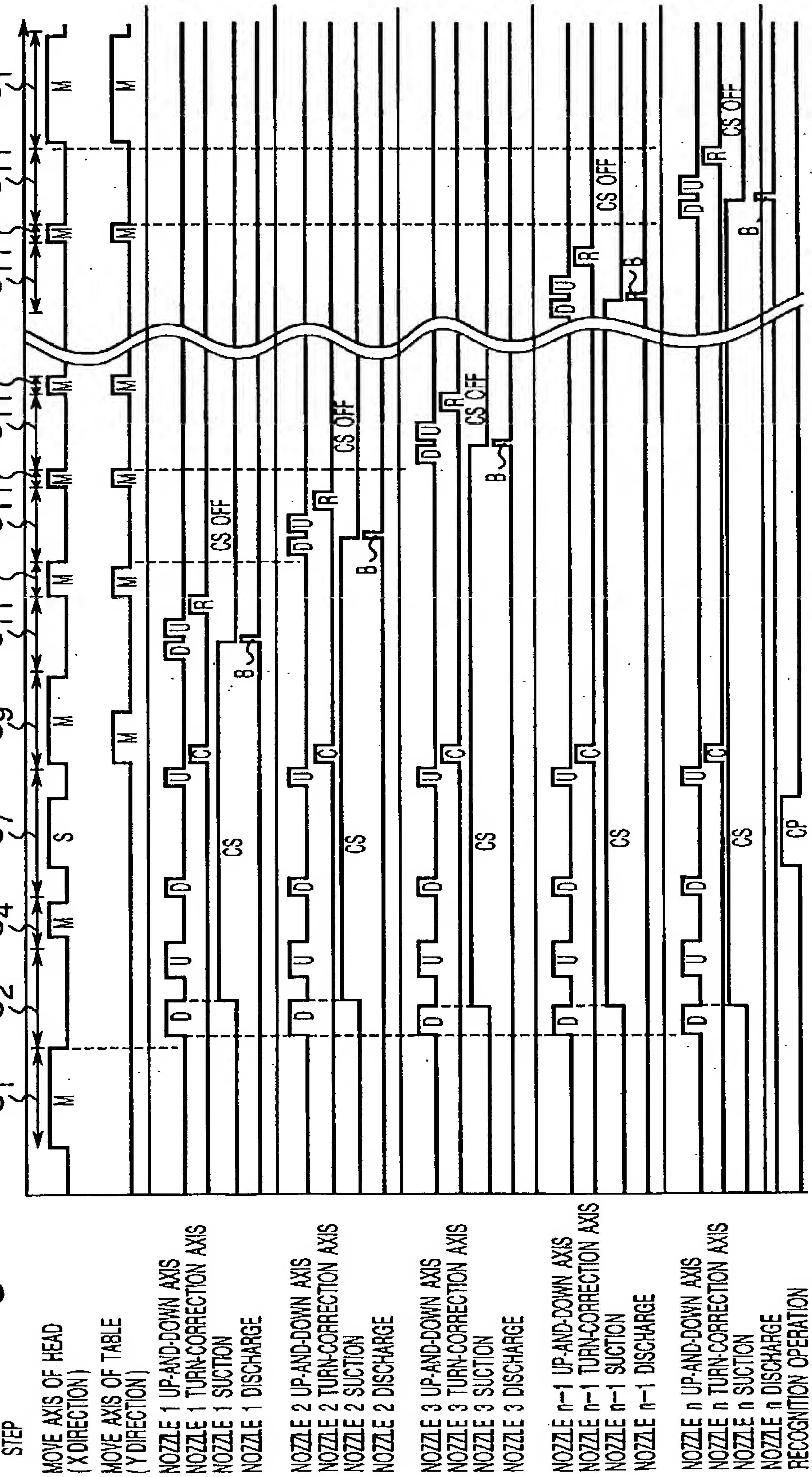
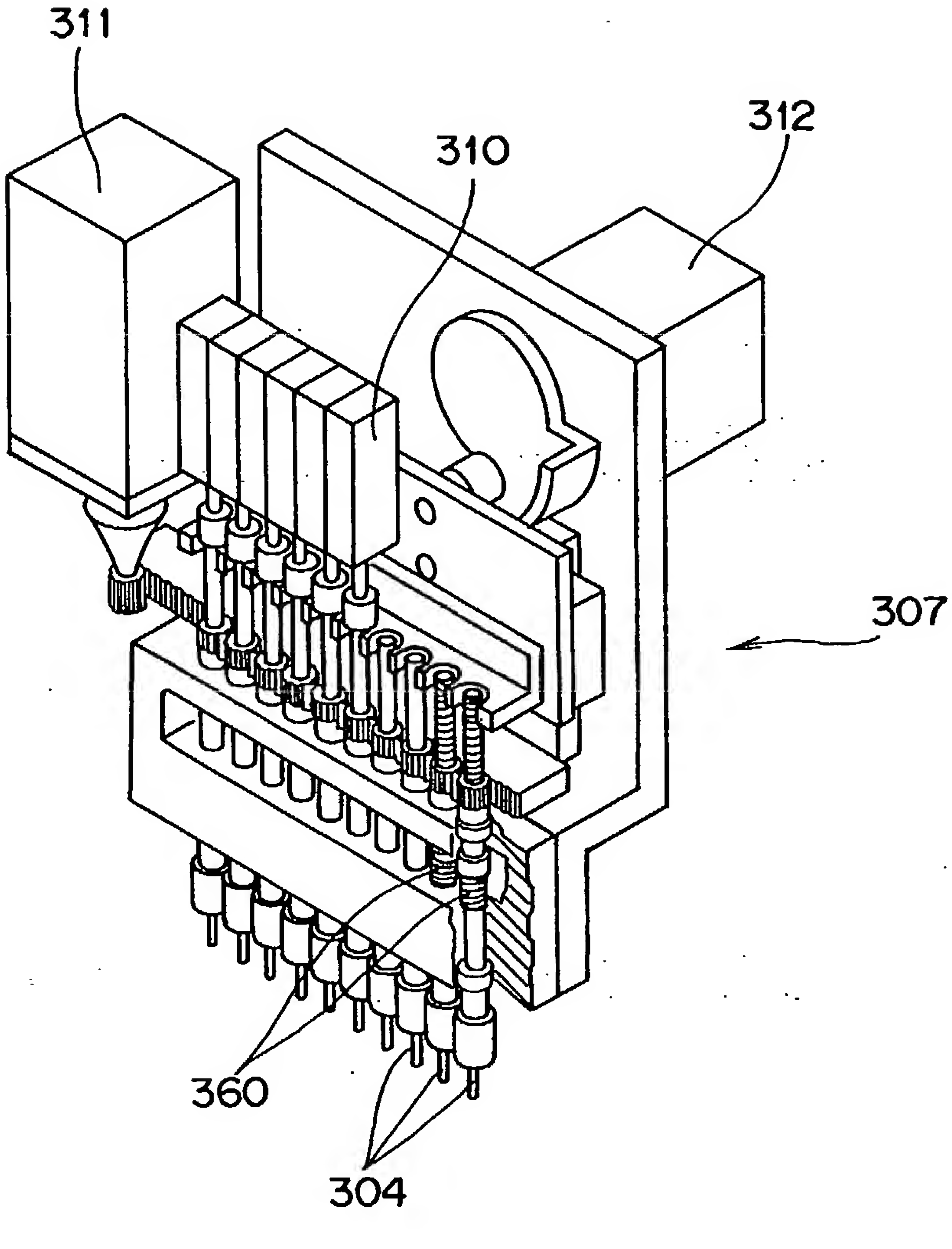

STEP
MOVE AXIS OF HEAD (X DIRECTION)
MOVE AXIS OF TABLE (Y DIRECTION)
NOZZLE 1 UP-AND-DOWN AXIS
NOZZLE 1 TURN-CORRECTION AXIS
NOZZLE 1 SUCTION
NOZZLE 1 DISCHARGE
NOZZLE 2 UP-AND-DOWN AXIS
NOZZLE 2 TURN-CORRECTION AXIS
NOZZLE 2 SUCTION
NOZZLE 2 DISCHARGE
NOZZLE 3 UP-AND-DOWN AXIS
NOZZLE 3 TURN-CORRECTION AXIS
NOZZLE 3 SUCTION
NOZZLE 3 DISCHARGE
NOZZLE n−1 UP-AND-DOWN AXIS
NOZZLE n−1 TURN-CORRECTION AXIS
NOZZLE n−1 SUCTION
NOZZLE n−1 DISCHARGE
NOZZLE n UP-AND-DOWN AXIS
NOZZLE n TURN-CORRECTION AXIS
NOZZLE n SUCTION
NOZZLE n DISCHARGE
RECOGNITION OPERATION
S1
S2
S4
S7
S9
S11
M
S
D
U
C
R
B
CS
CS OFF
CP

Fig. 22



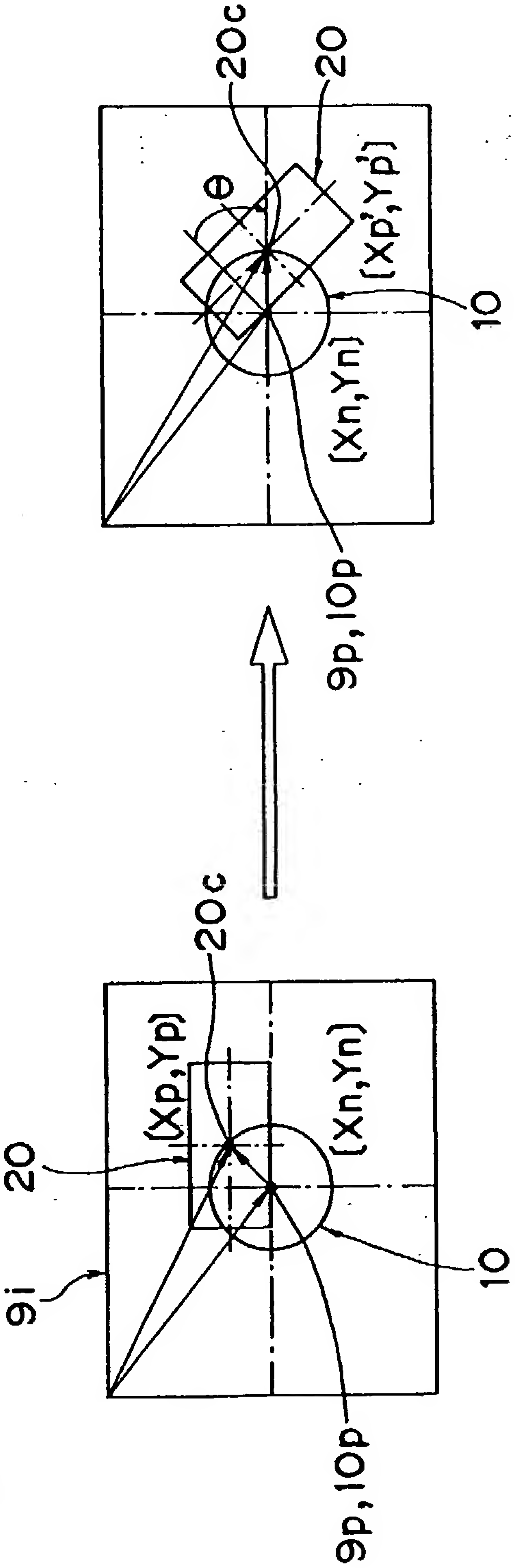


Fig.23A

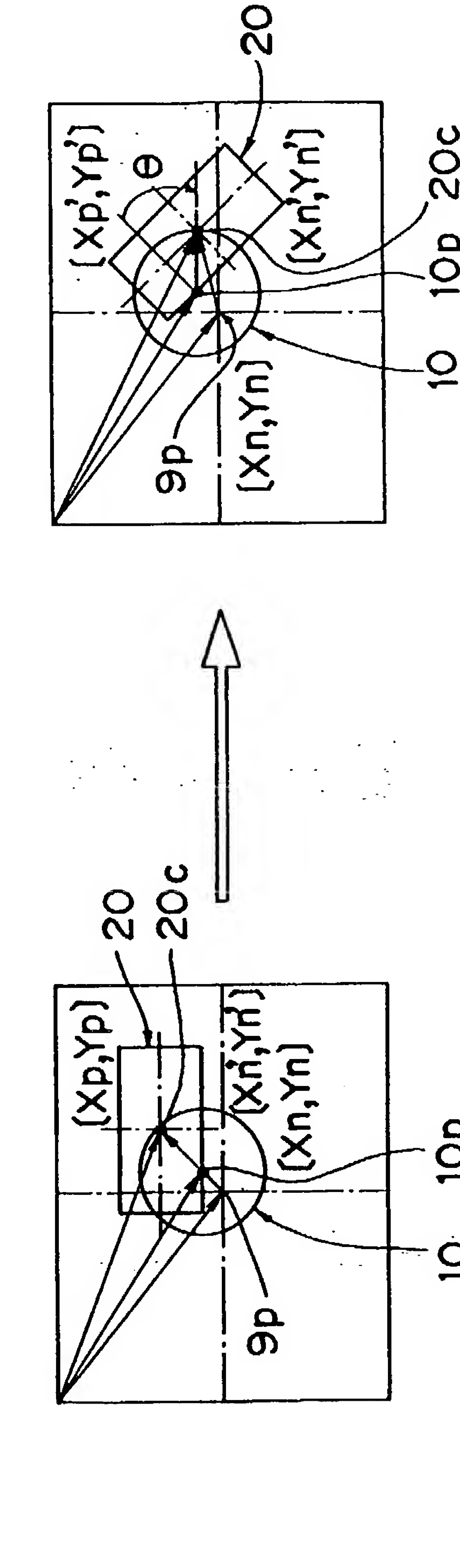


Fig.23B

Fig. 24

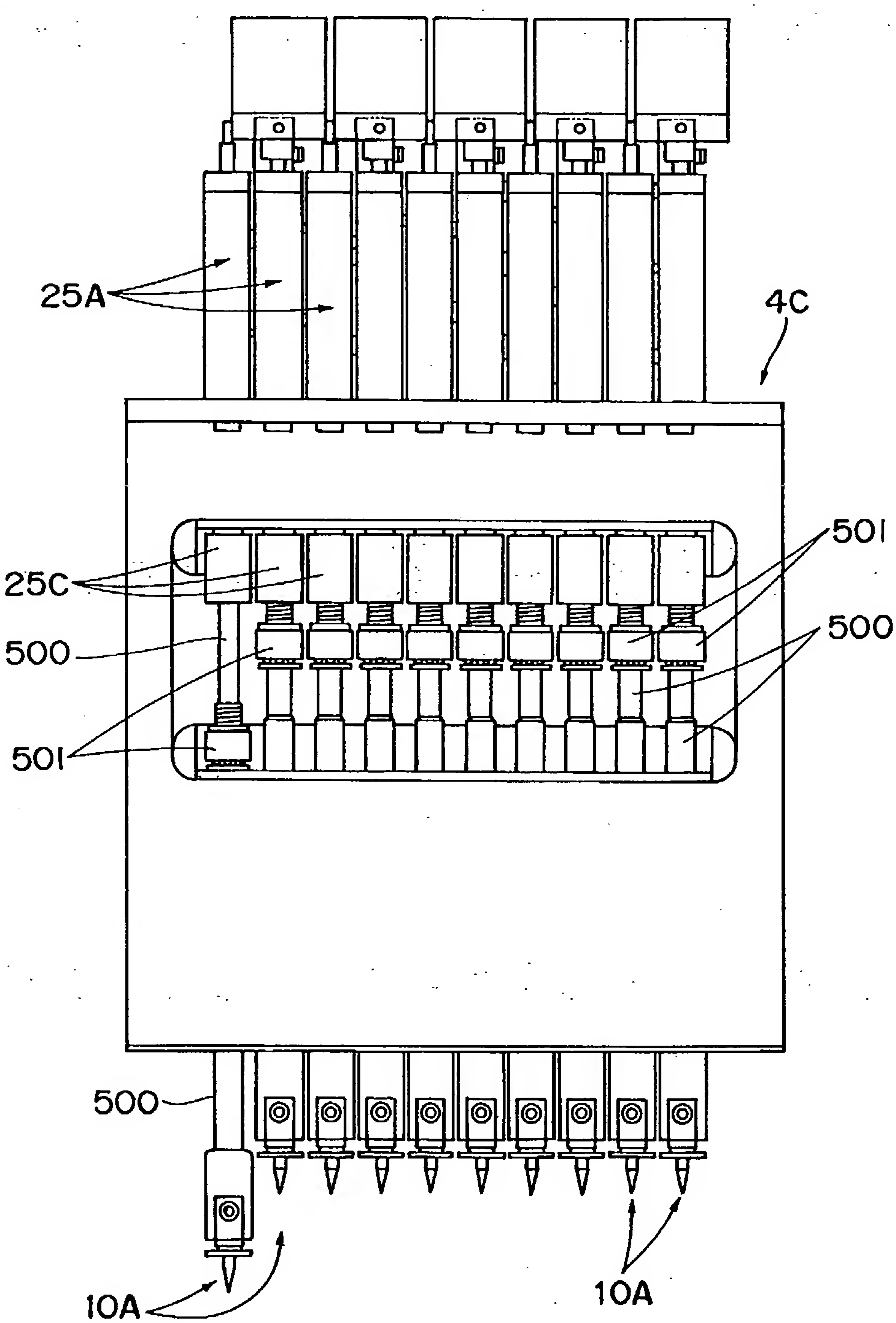


Fig. 25

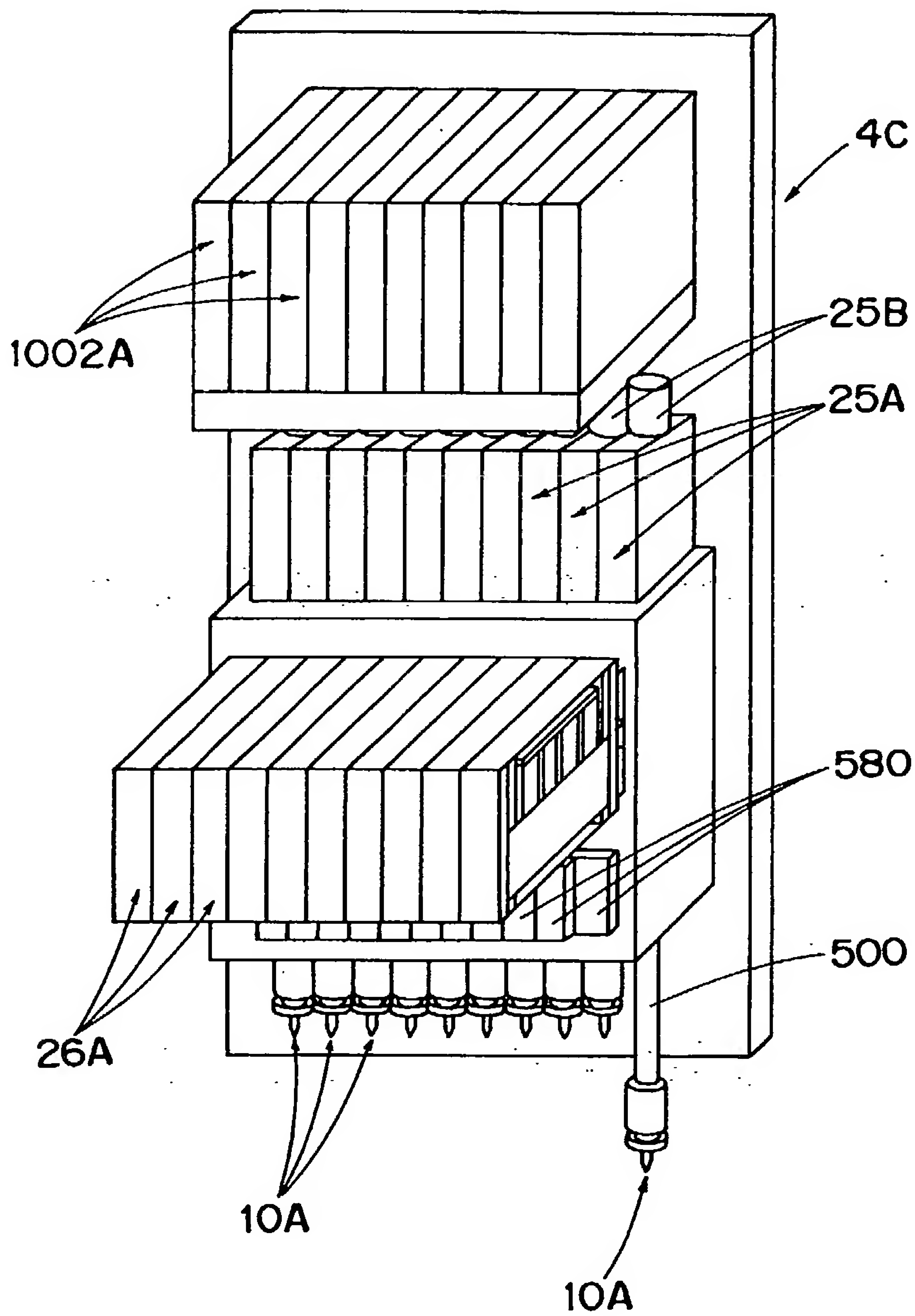


Fig. 26

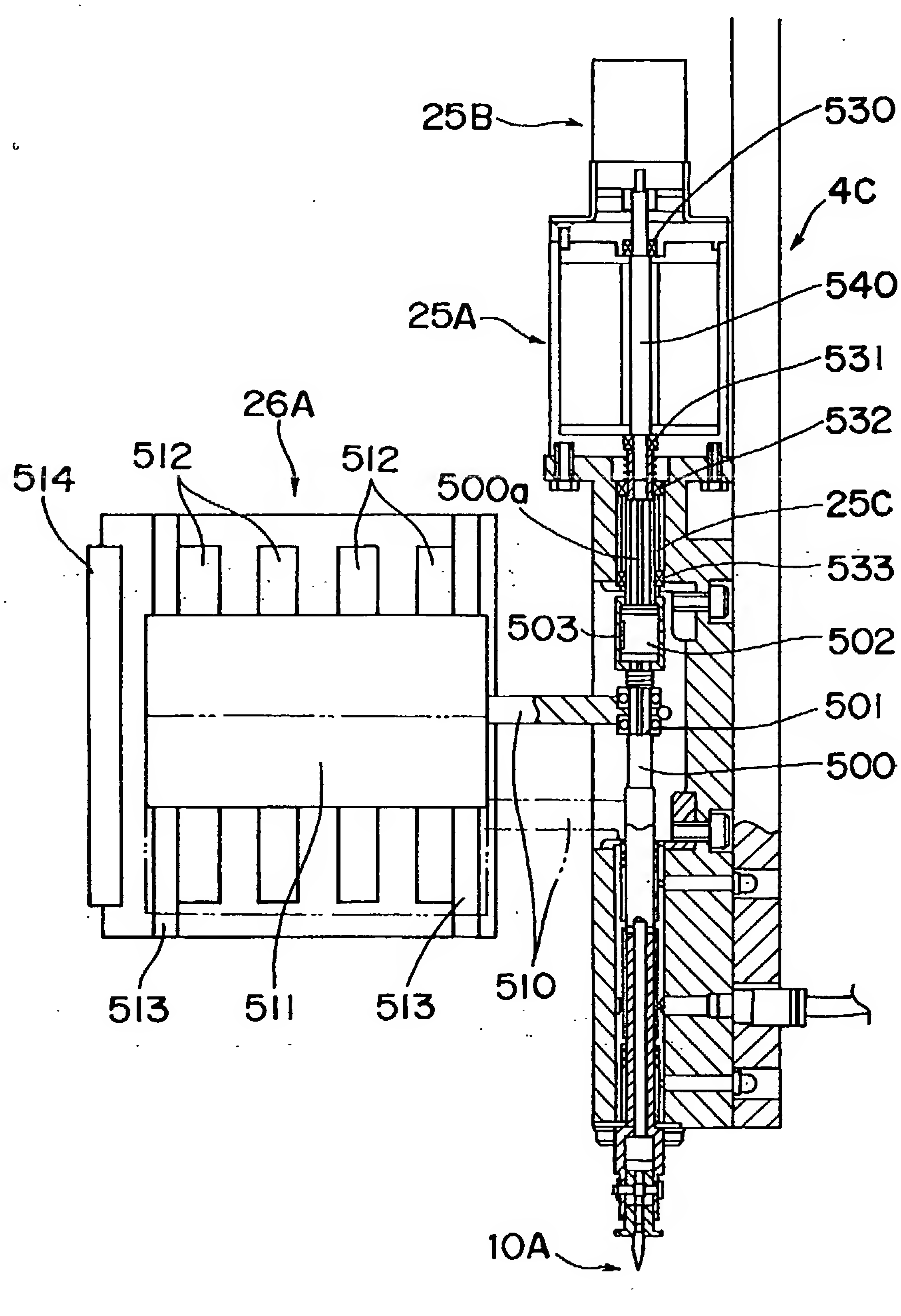

25B
530
4C
540
25A
531
26A
532
512
512
514
500a
25C
533
503
502
501
500
510
513
511
513
10A

Fig. 27

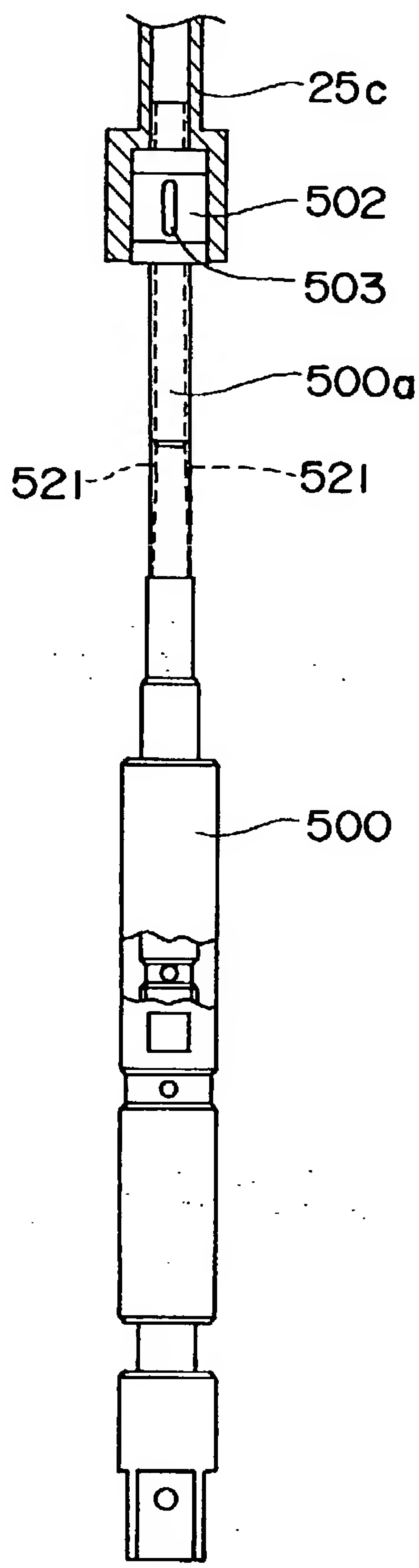


Fig. 28

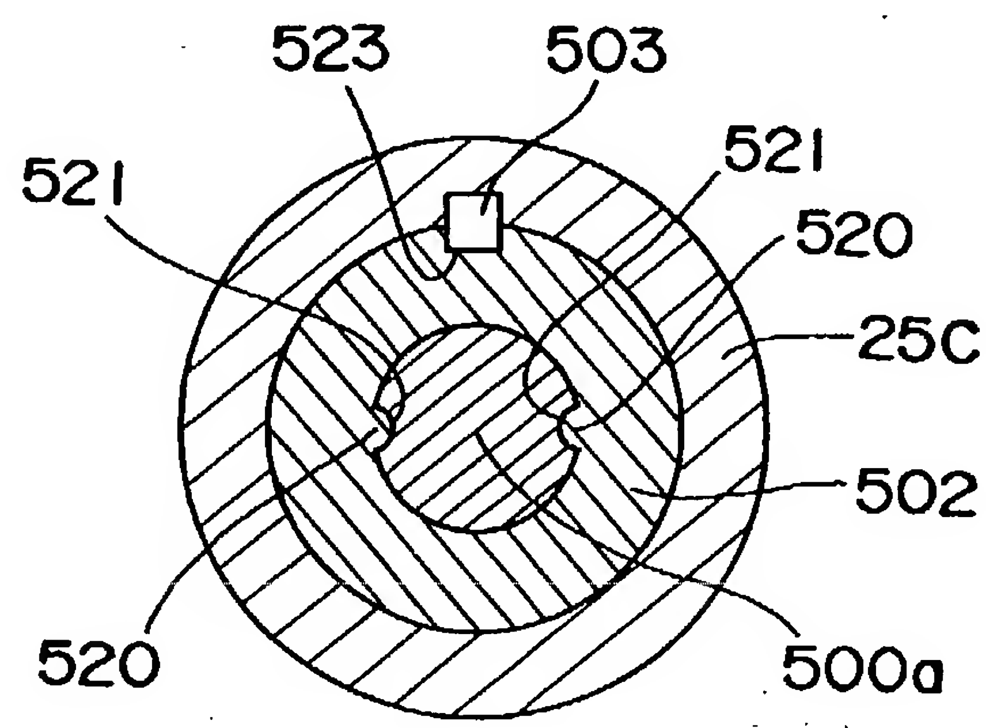


Fig. 29

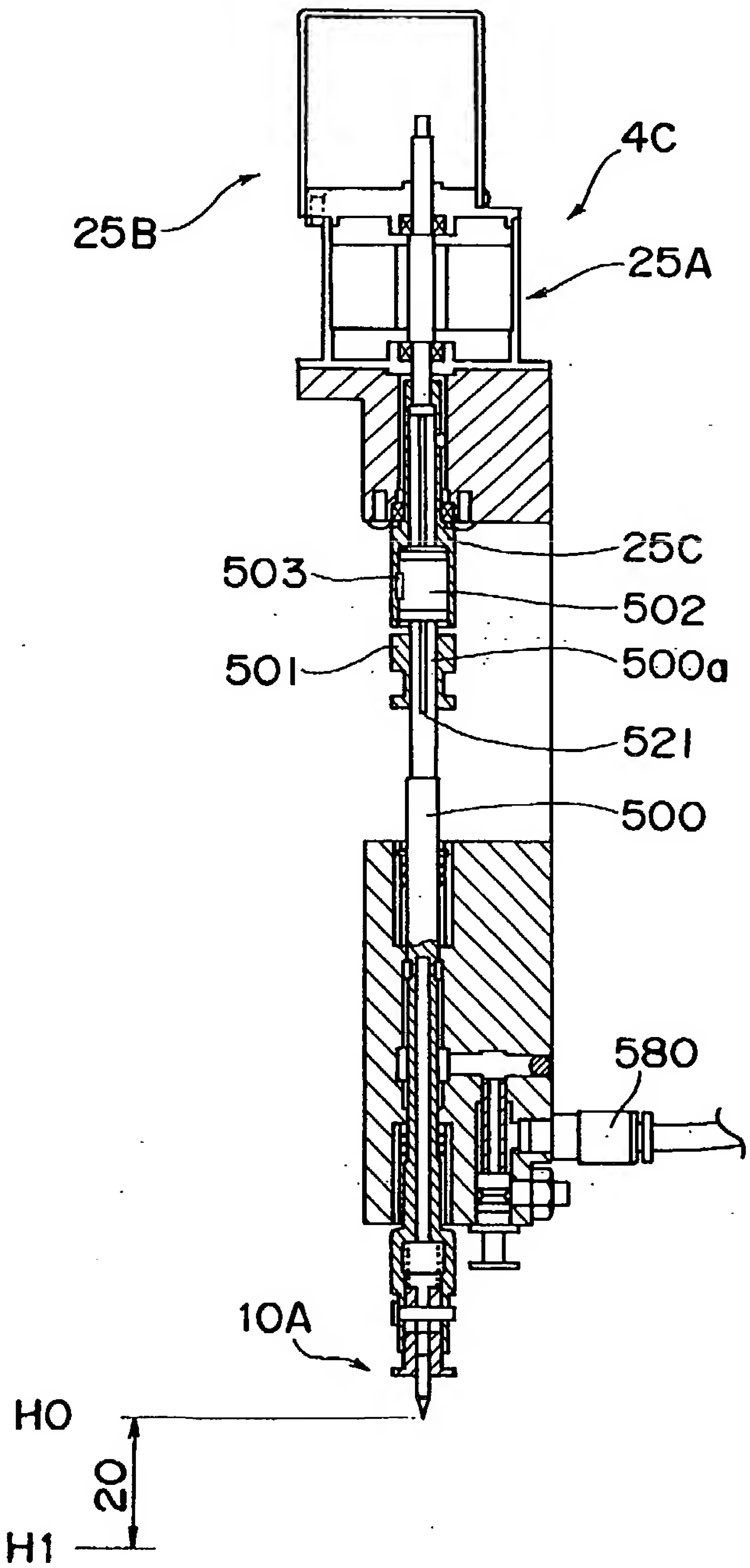


Fig. 30

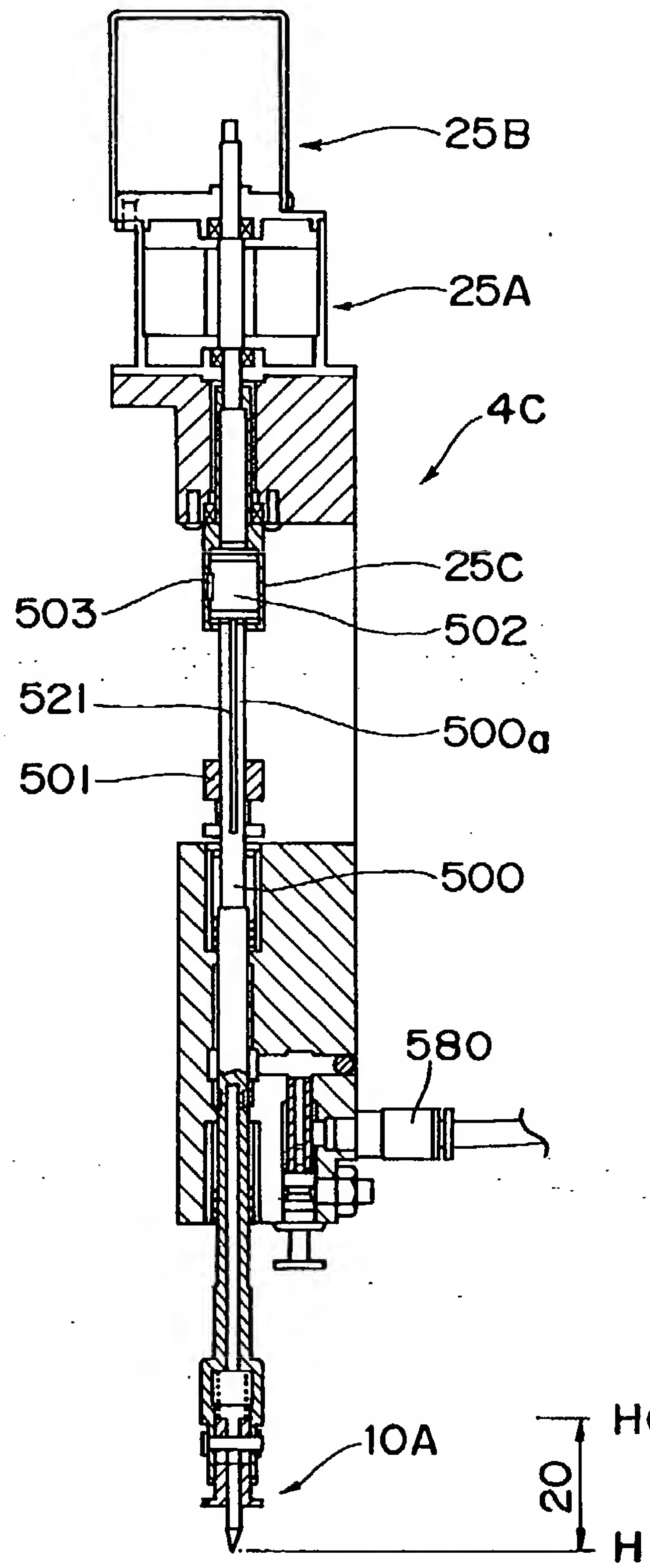


Fig. 31

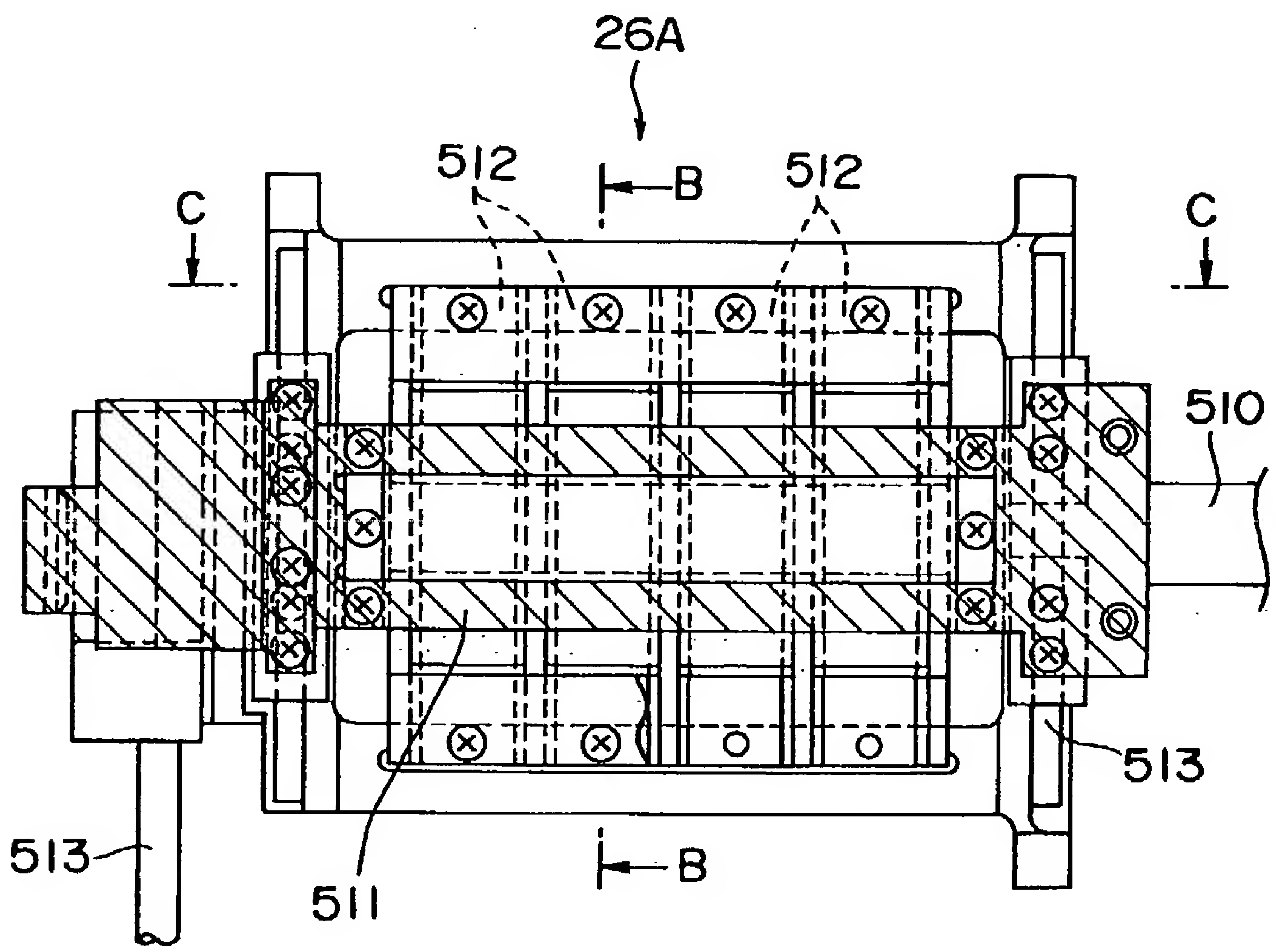


Fig. 32

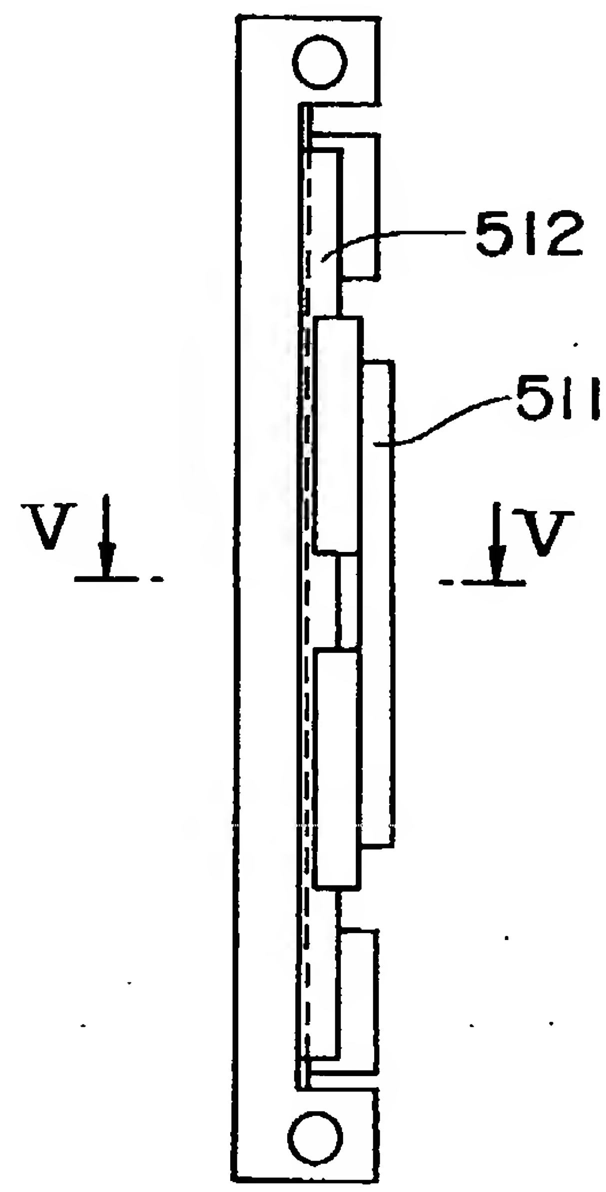


Fig. 33

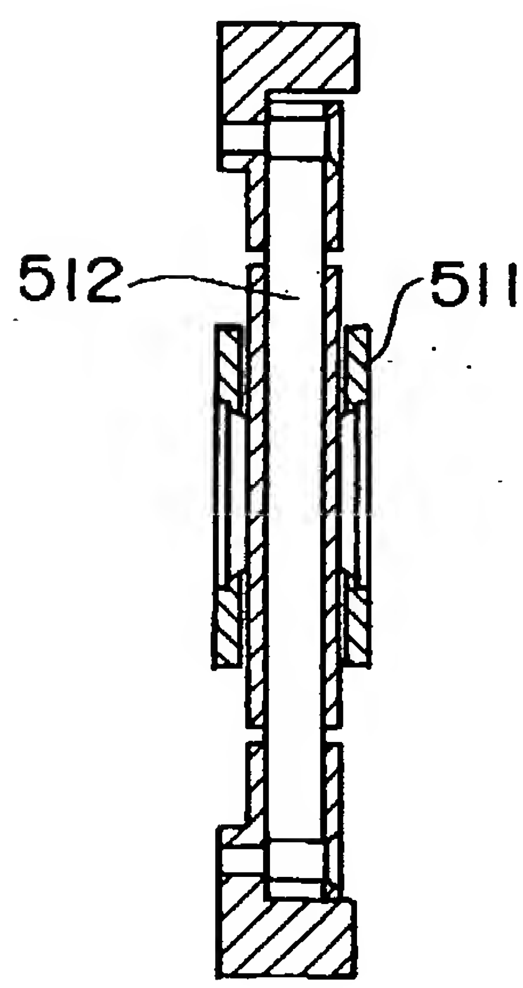


Fig.34

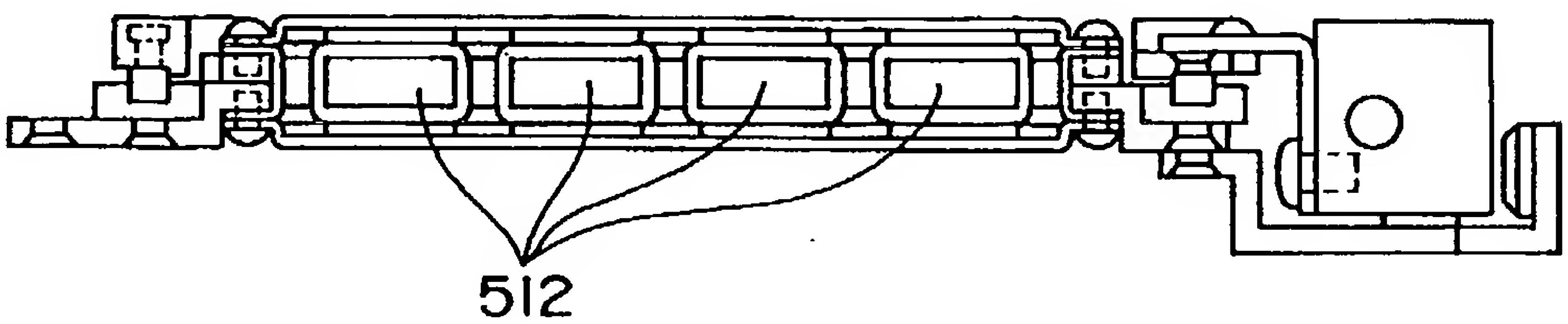


Fig.35

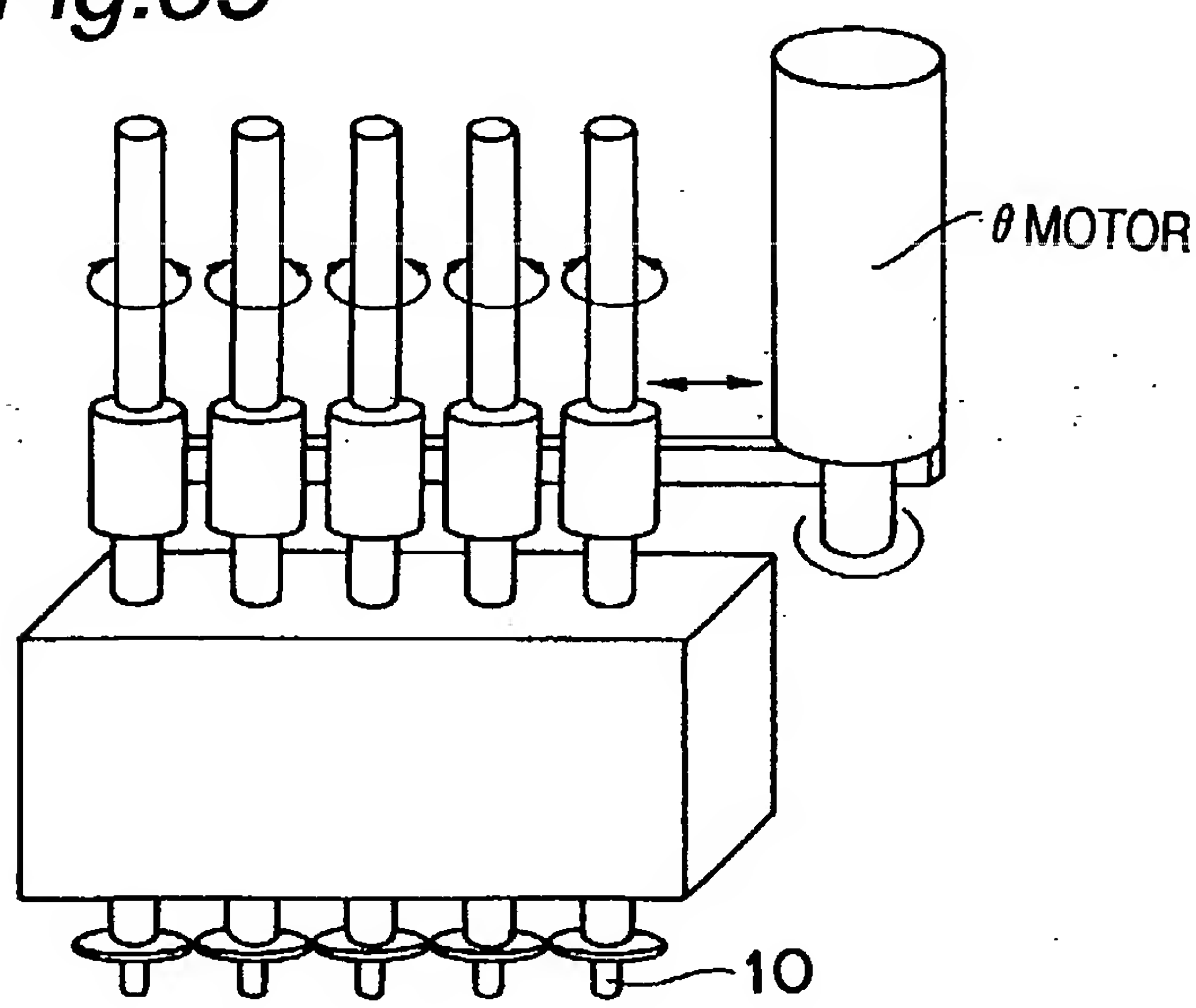


Fig.36A

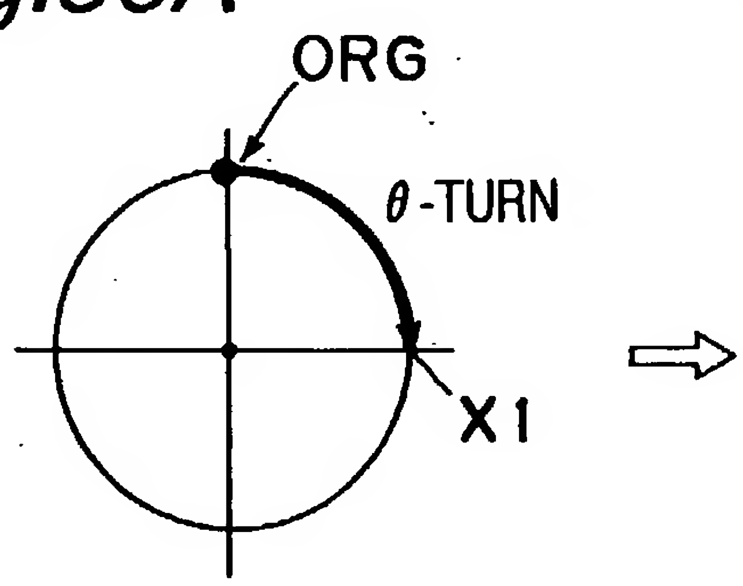


Fig.36B

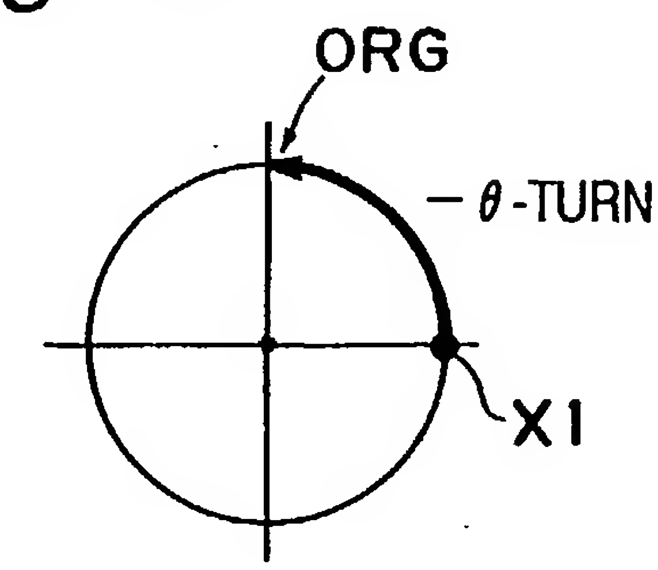


Fig.37

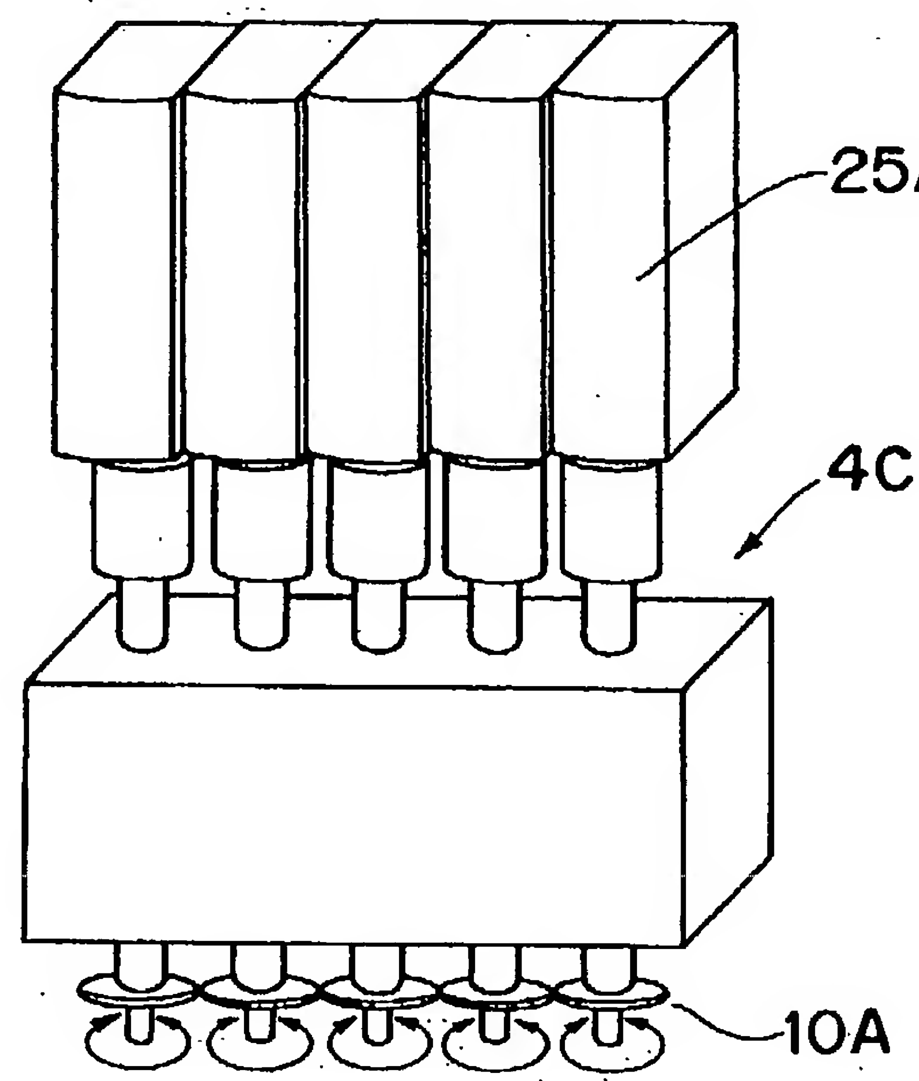


Fig.38A

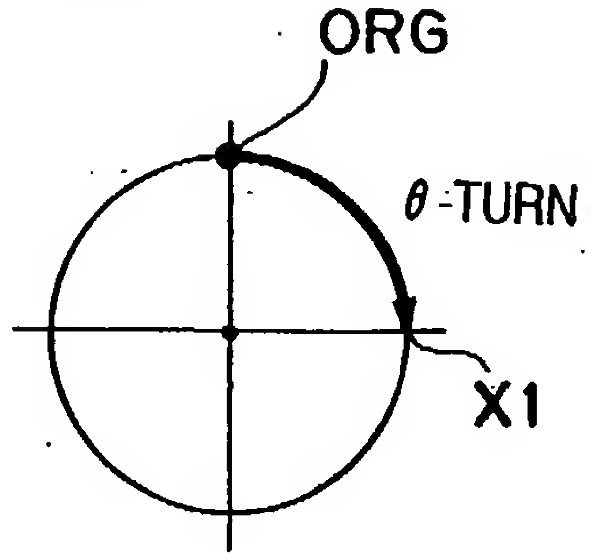
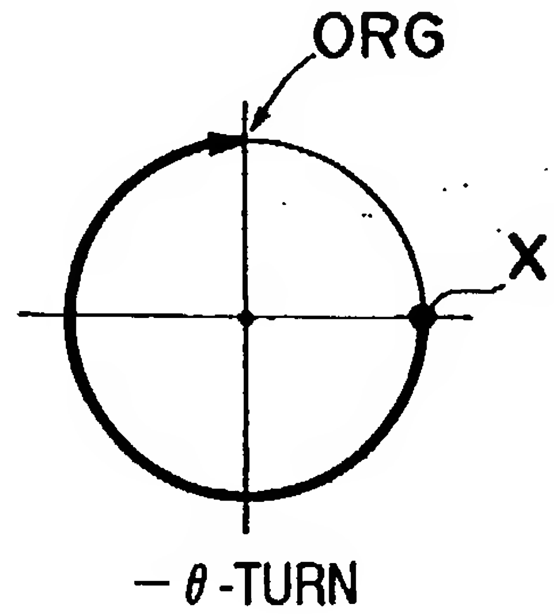


Fig.38B



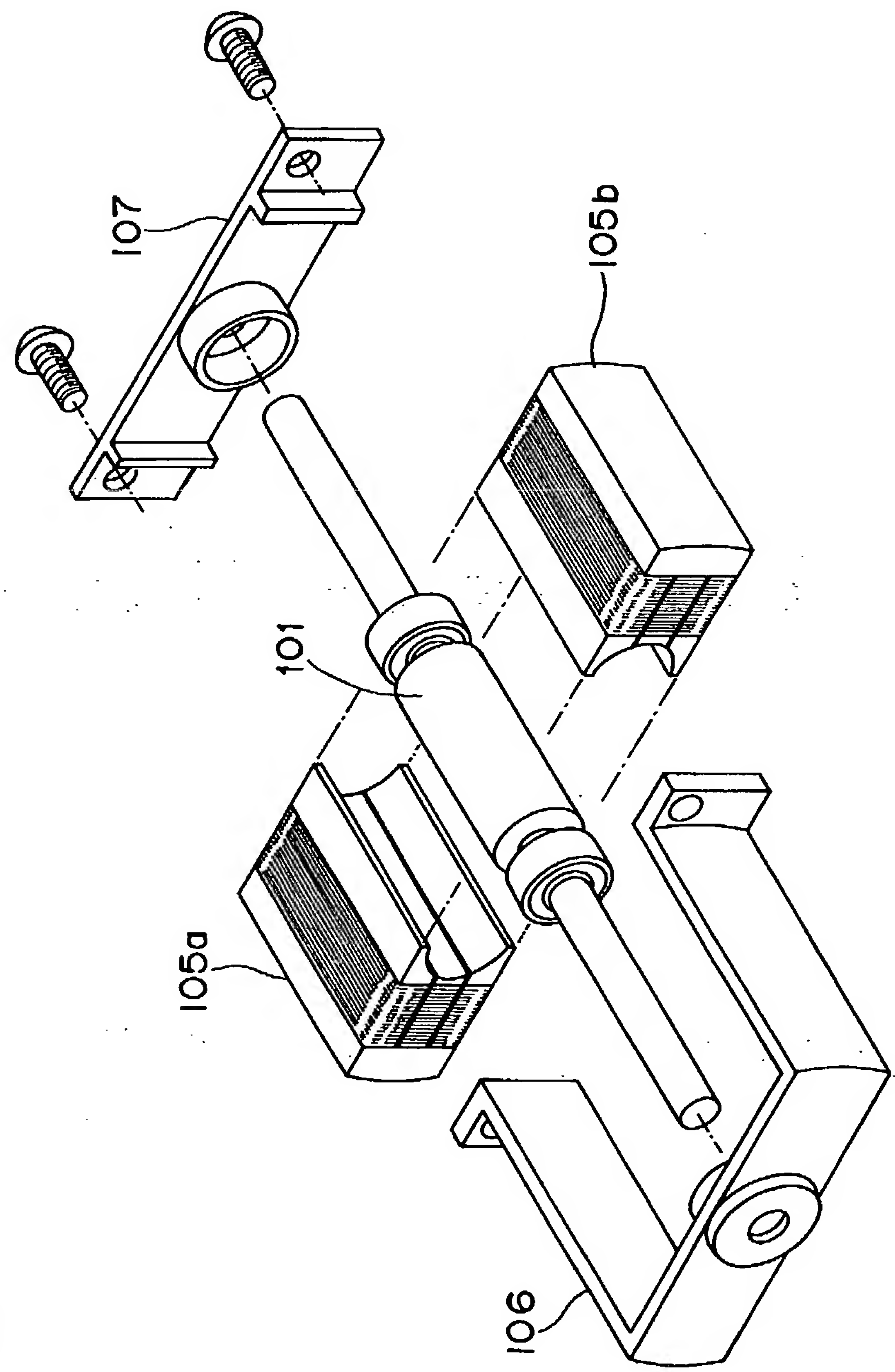


Fig. 39

Fig. 40

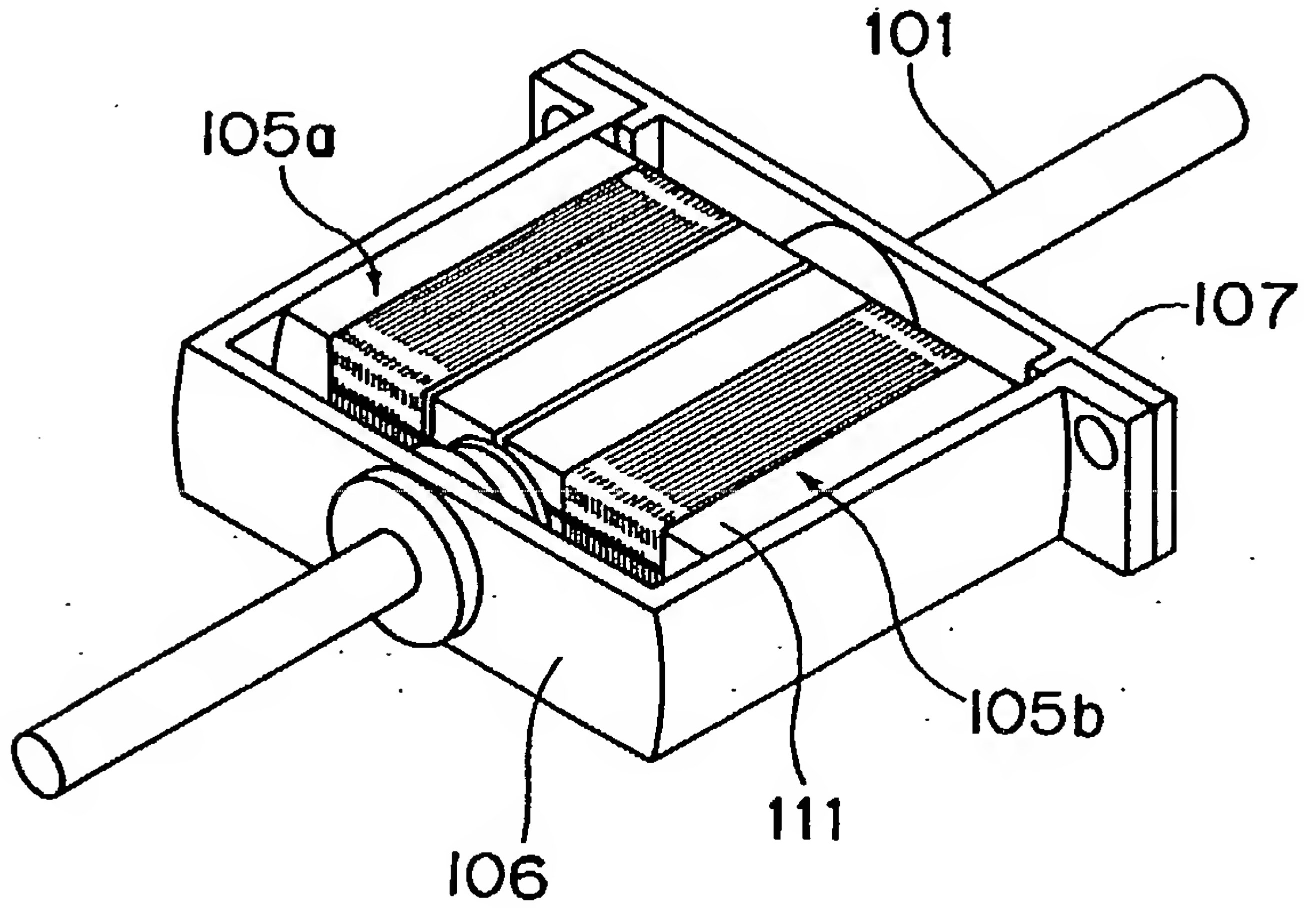


Fig. 41

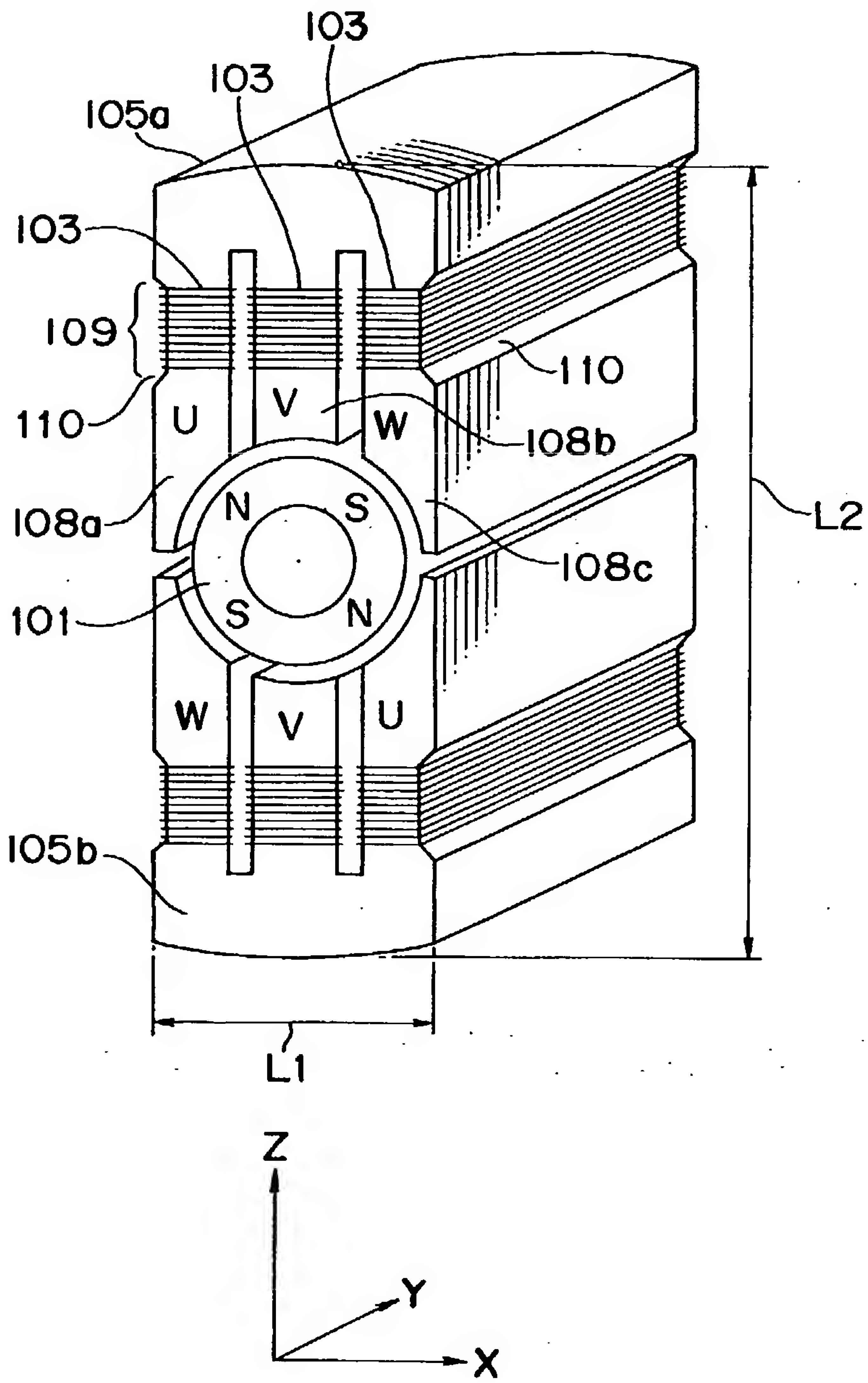

103
103
105a
103
109
110
U
V
W
108b
110
108a
N
S
108c
L2
101
S
N
W
V
U
105b
L1
Z
Y
X

Fig. 42

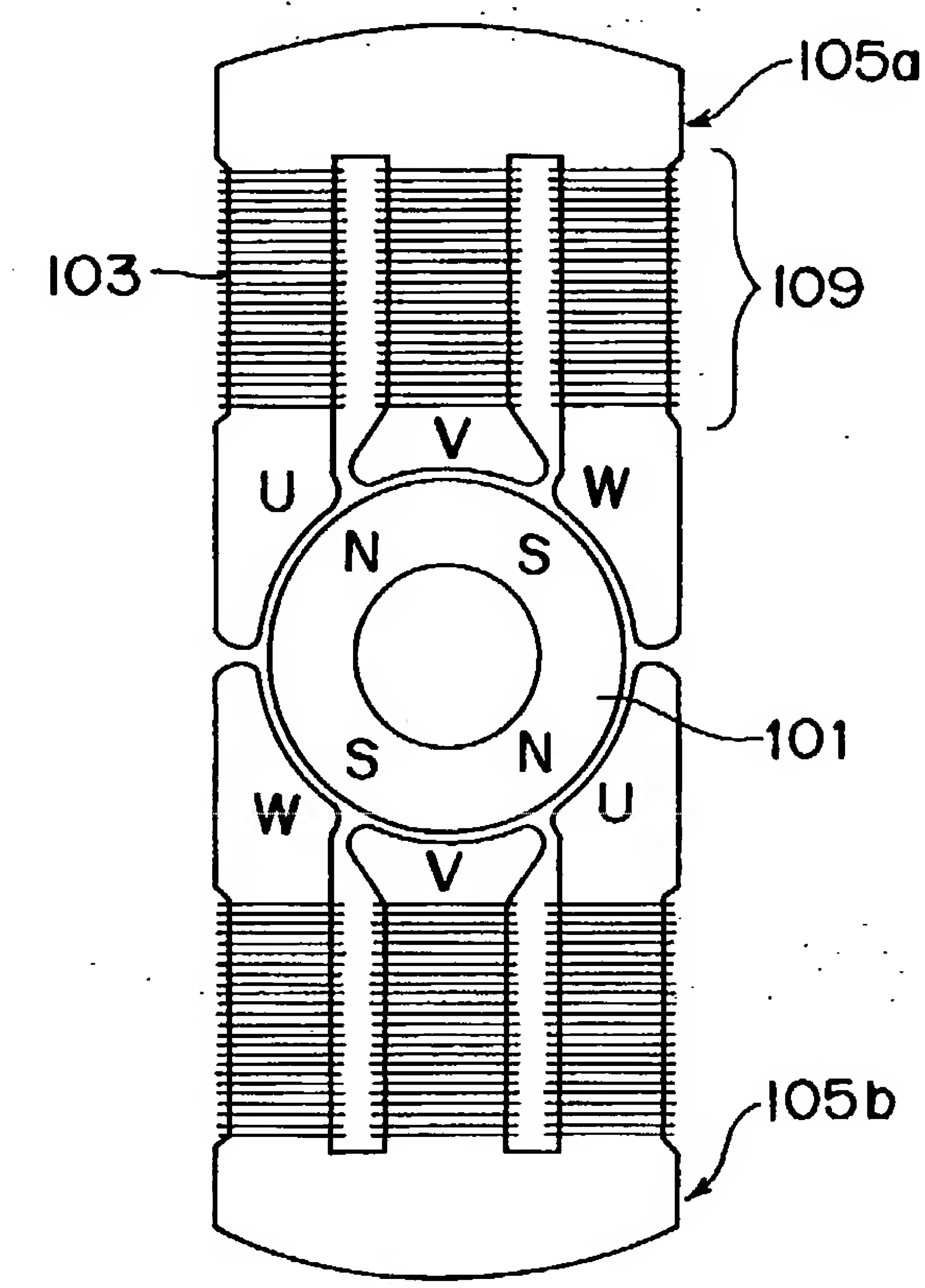


Fig. 43

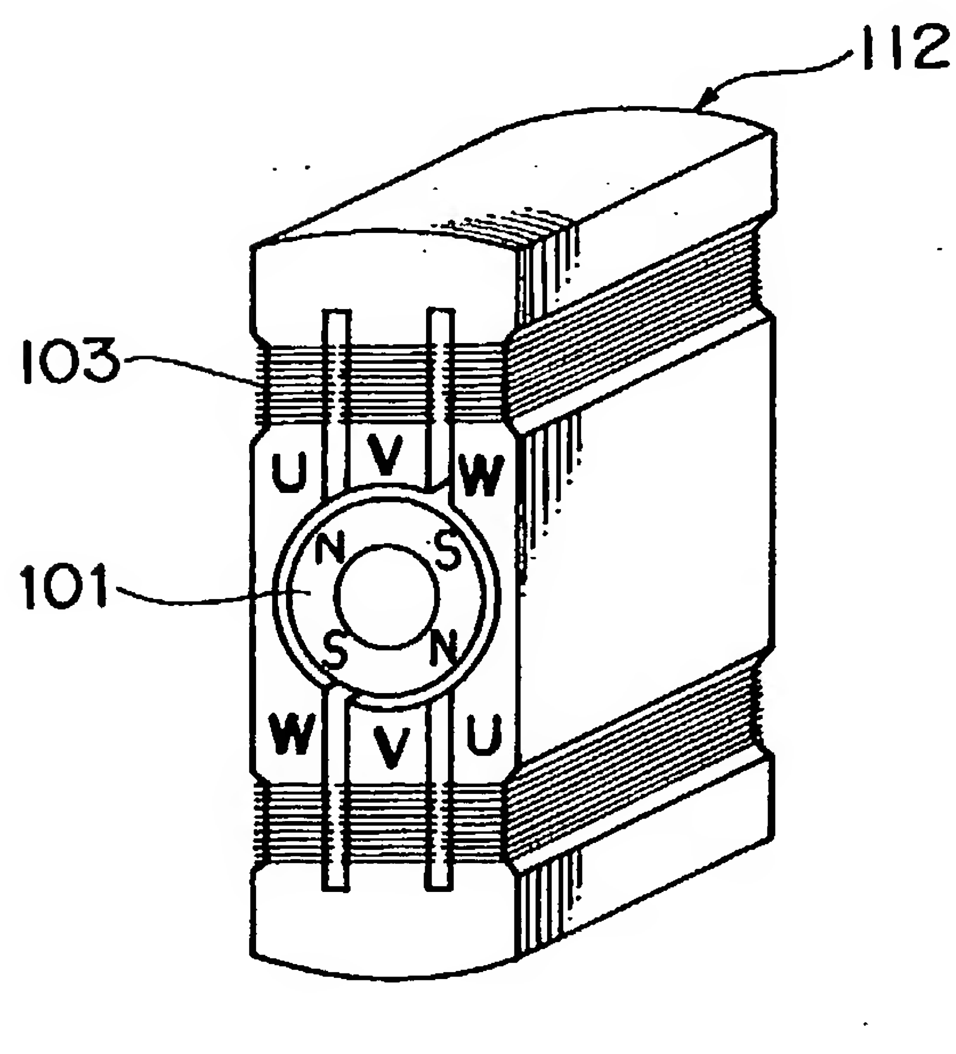


Fig.44A

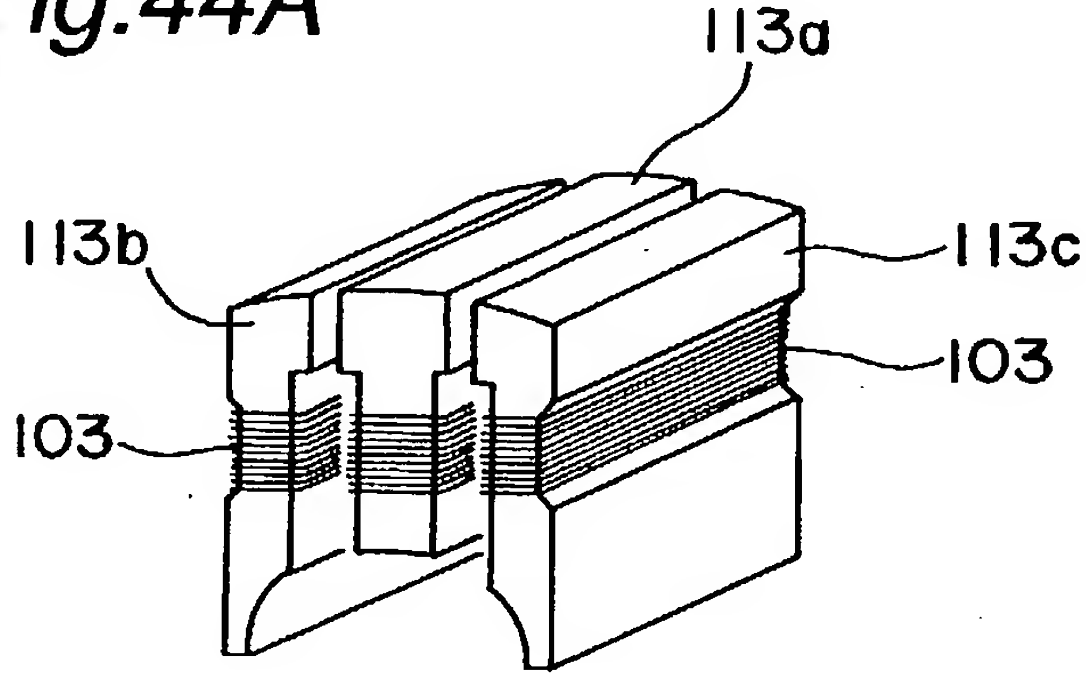


Fig.44B

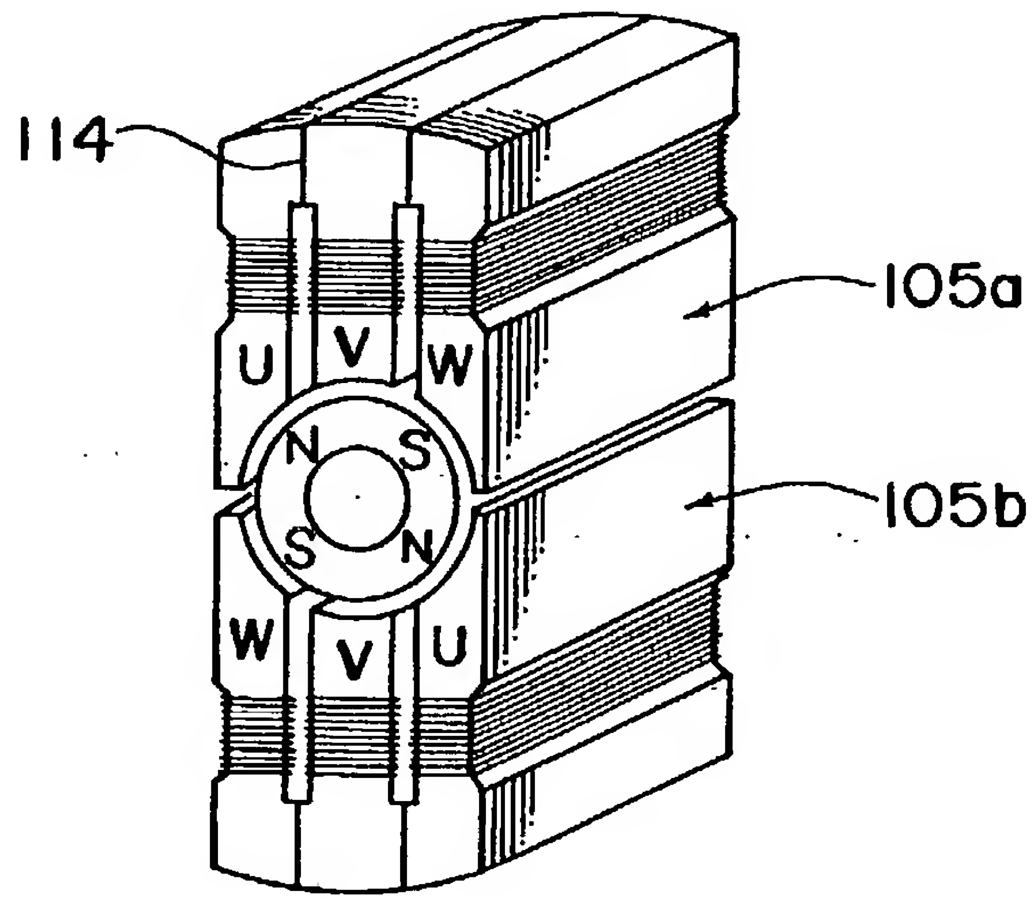


Fig. 45

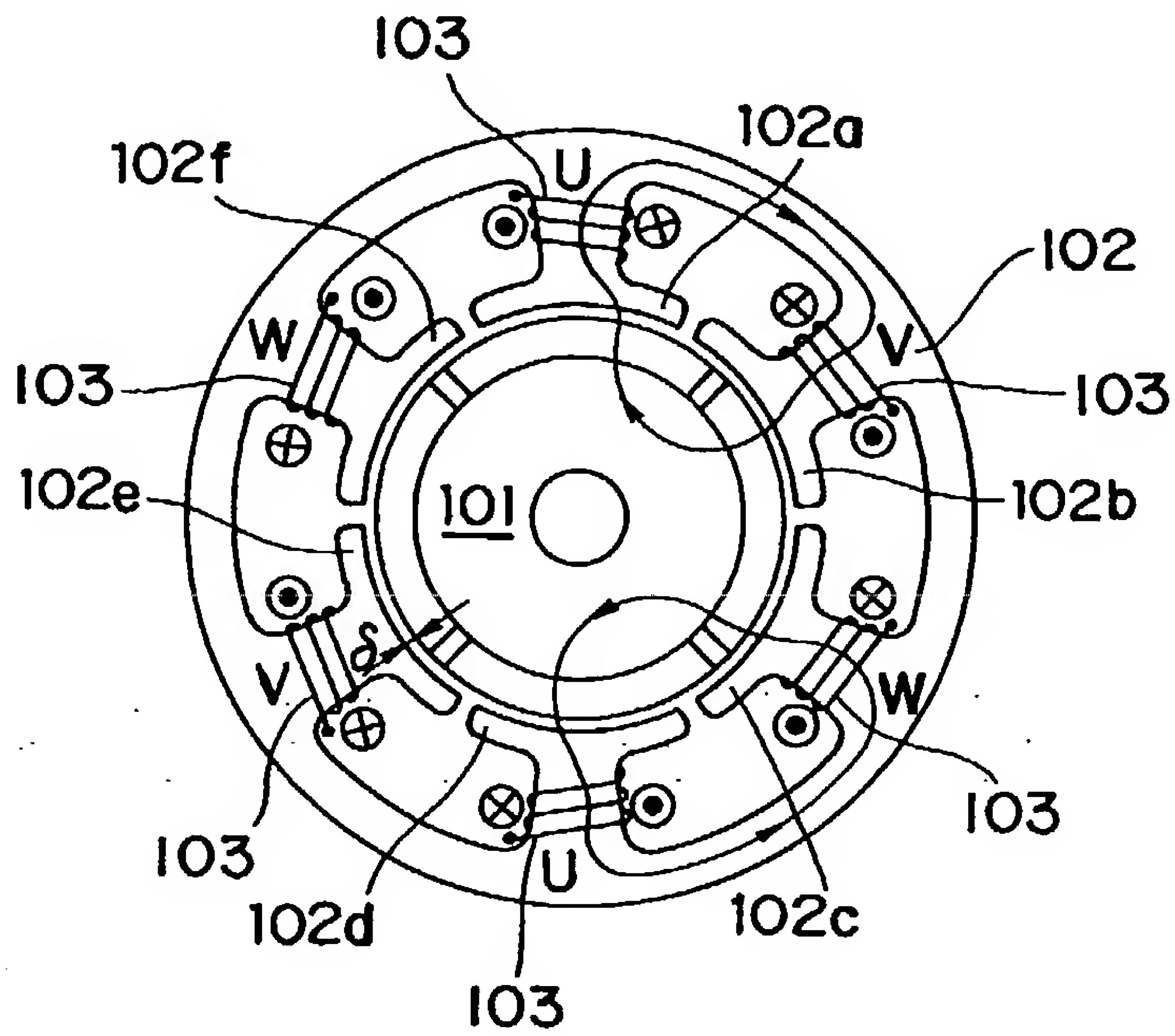

103
102a
102f
U
102
W
V
103
103
102e
101
102b
δ
V
W
103
103
U
102d
102c
103

Fig.46A

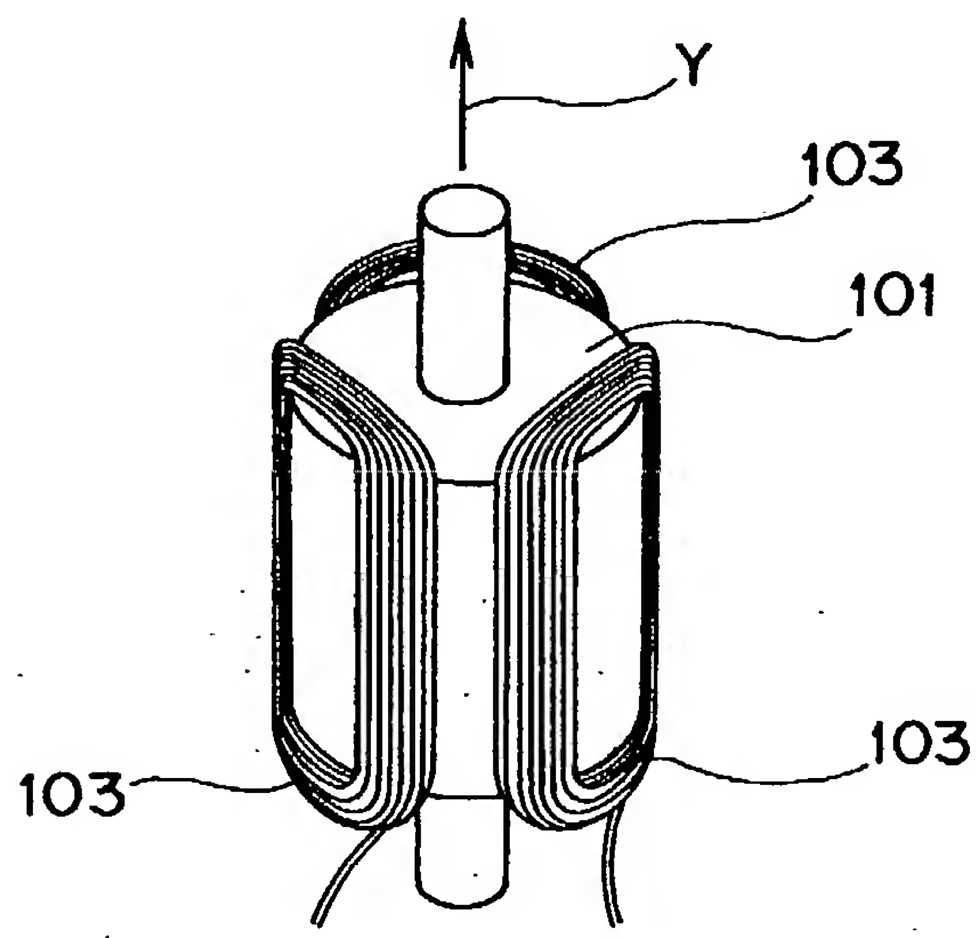
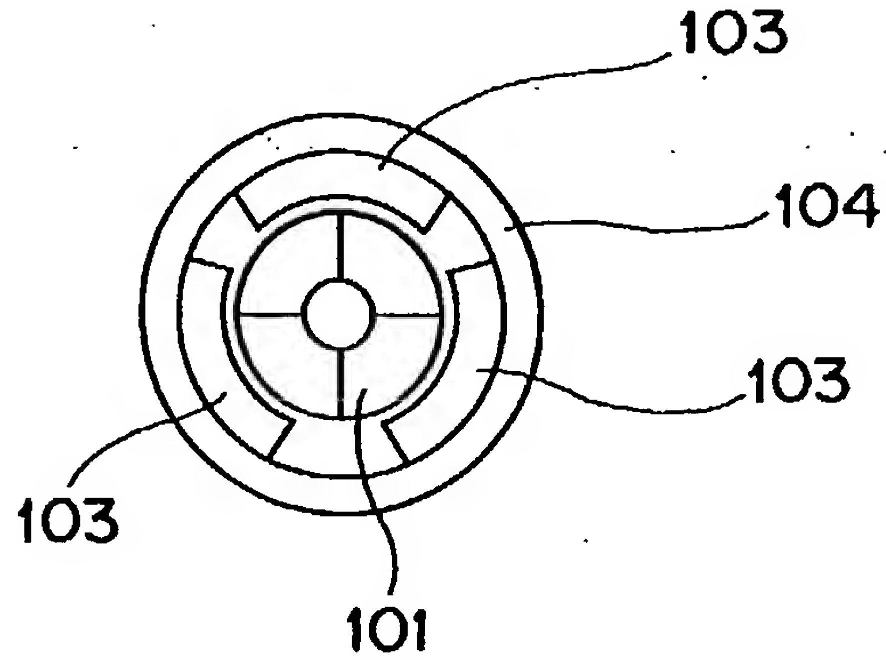


Fig.46B



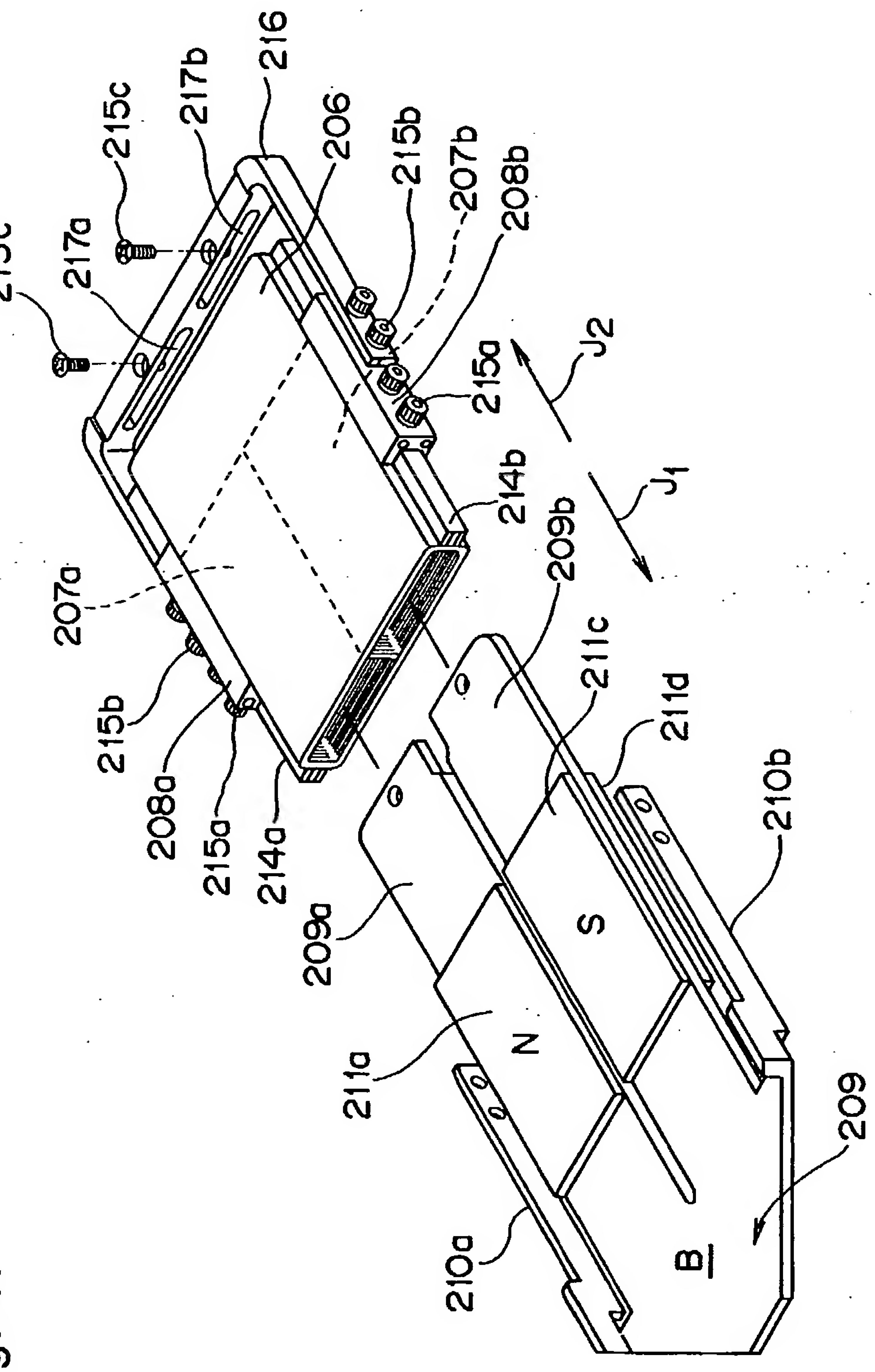
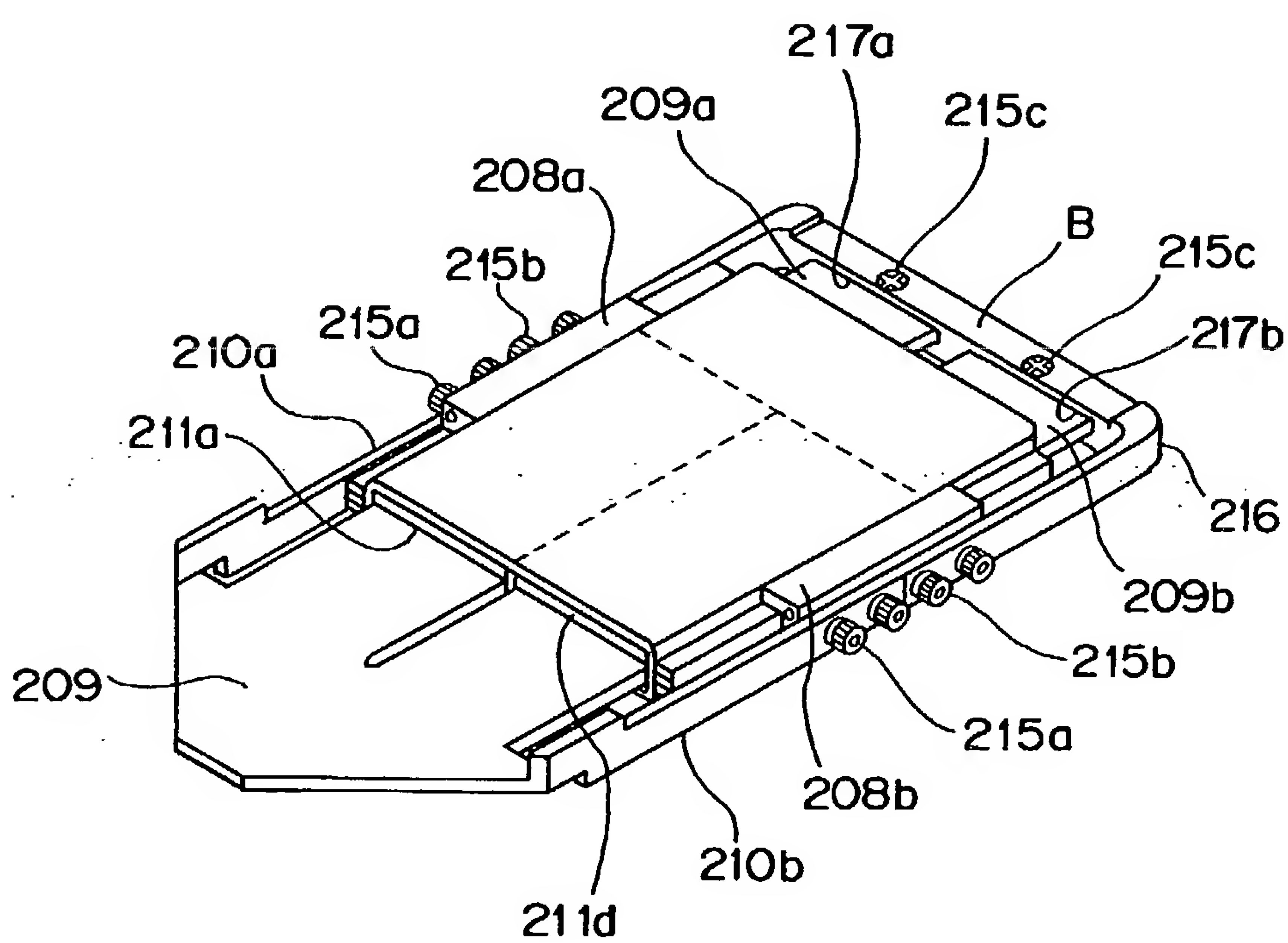

215c
215c
217a
217b
216
206
215b
207b
208b
215a
J2
J1
214b
209b
207a
215b
208a
215a
214a
211c
211d
210b
209a
S
N
211a
209
B
210a

Fig. 47

Fig. 48


217a
209a
215c
208a
B
215b
215c
215a
217b
210a
211a
216
209b
215b
209
215a
208b
210b
211d

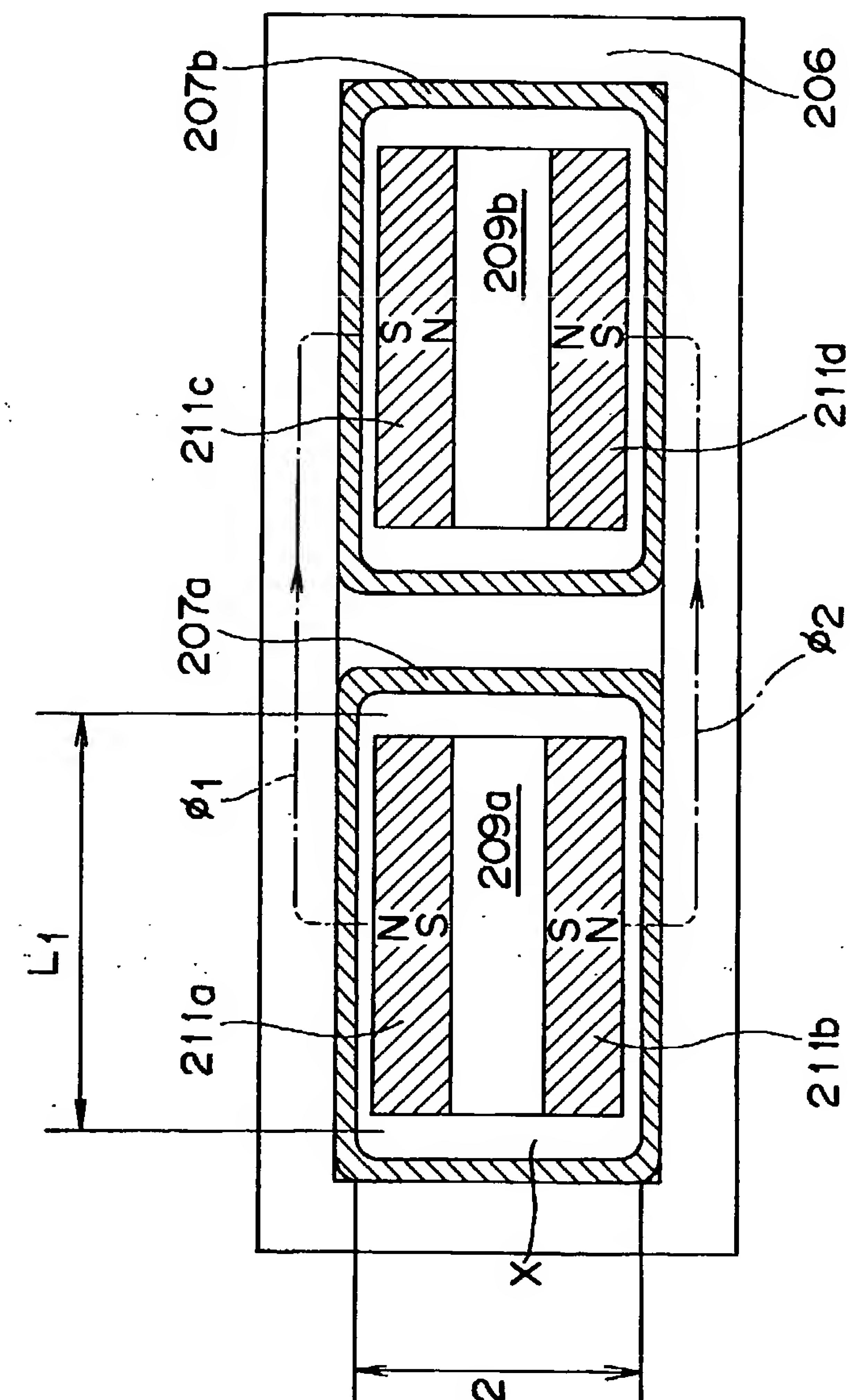


Fig. 49

Fig. 50

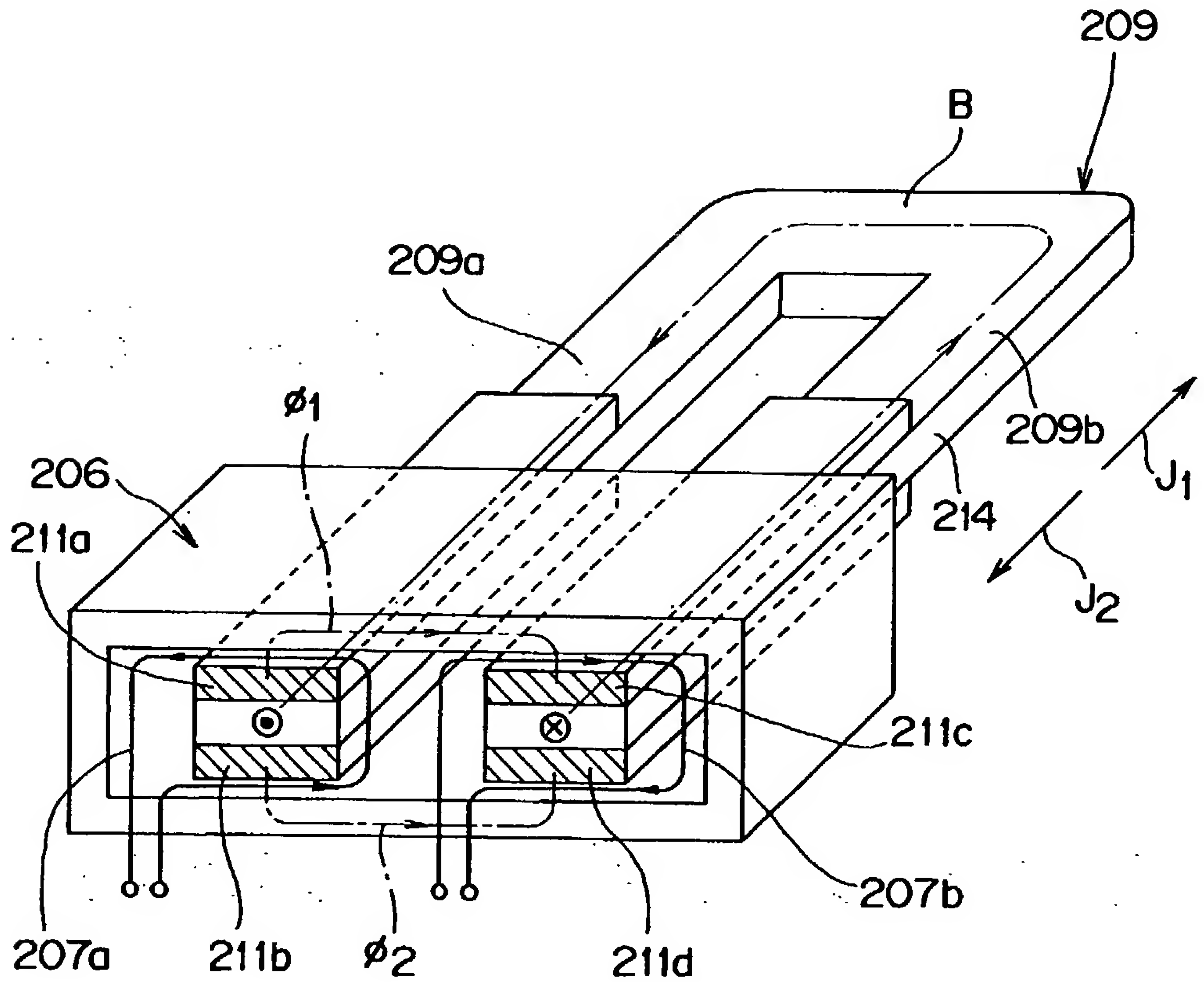

209
B
209a
ϕ_1
209b
J_1
206
211a
214
J_2
211c
207b
207a
211b
ϕ_2
211d

Fig. 51

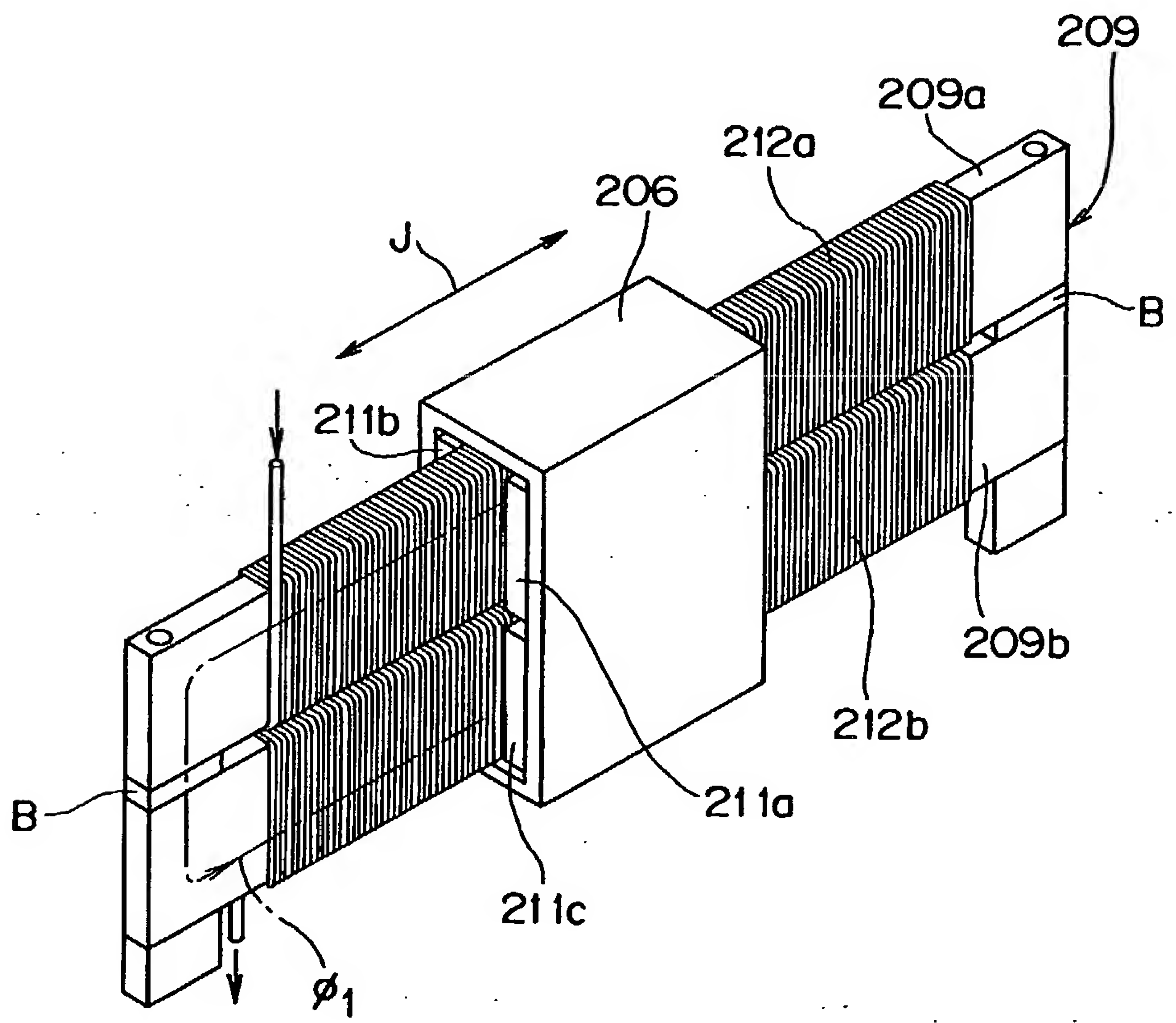
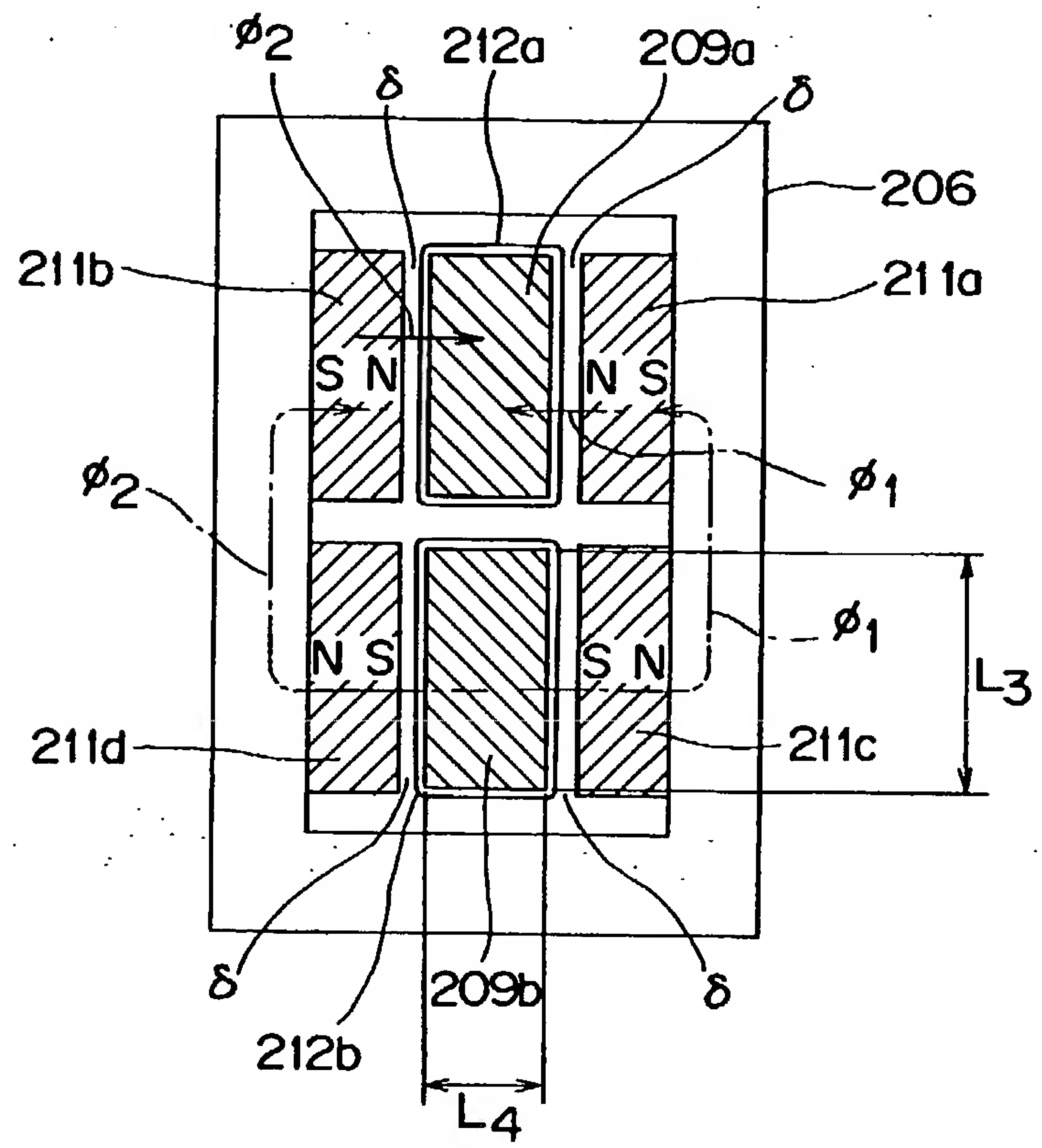
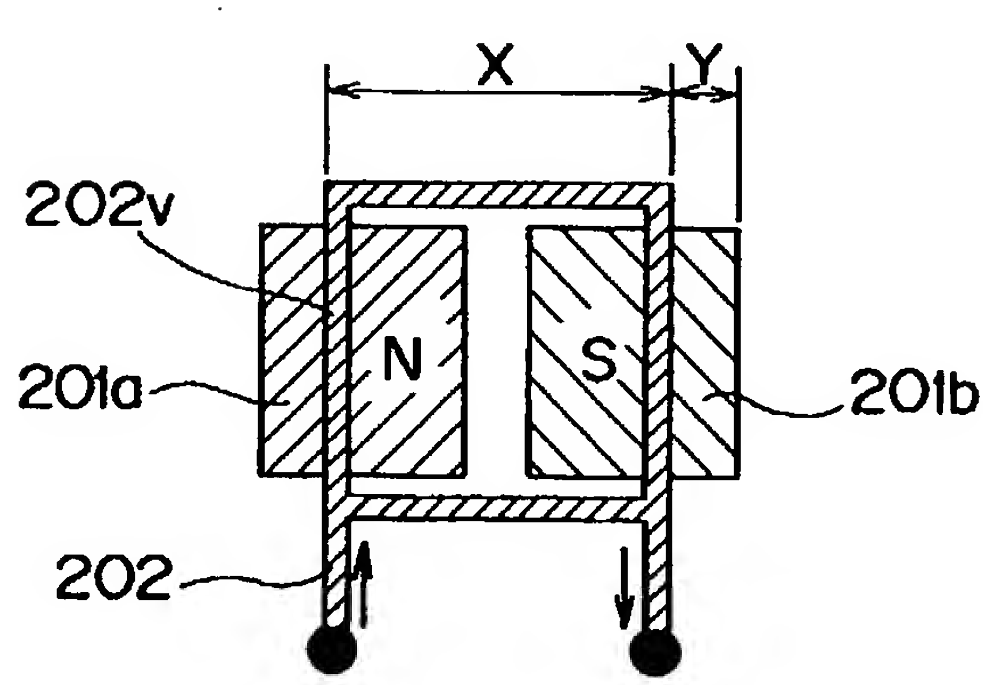


Fig. 52



φ2
δ
212a
209a
δ
206
211b
211a
S N
N S
φ2
φ1
φ1
N S
S N
L3
211d
211c
δ
212b
209b
δ
L4

Fig. 53



X
Y
202v
201a
N
S
201b
202

Fig. 54

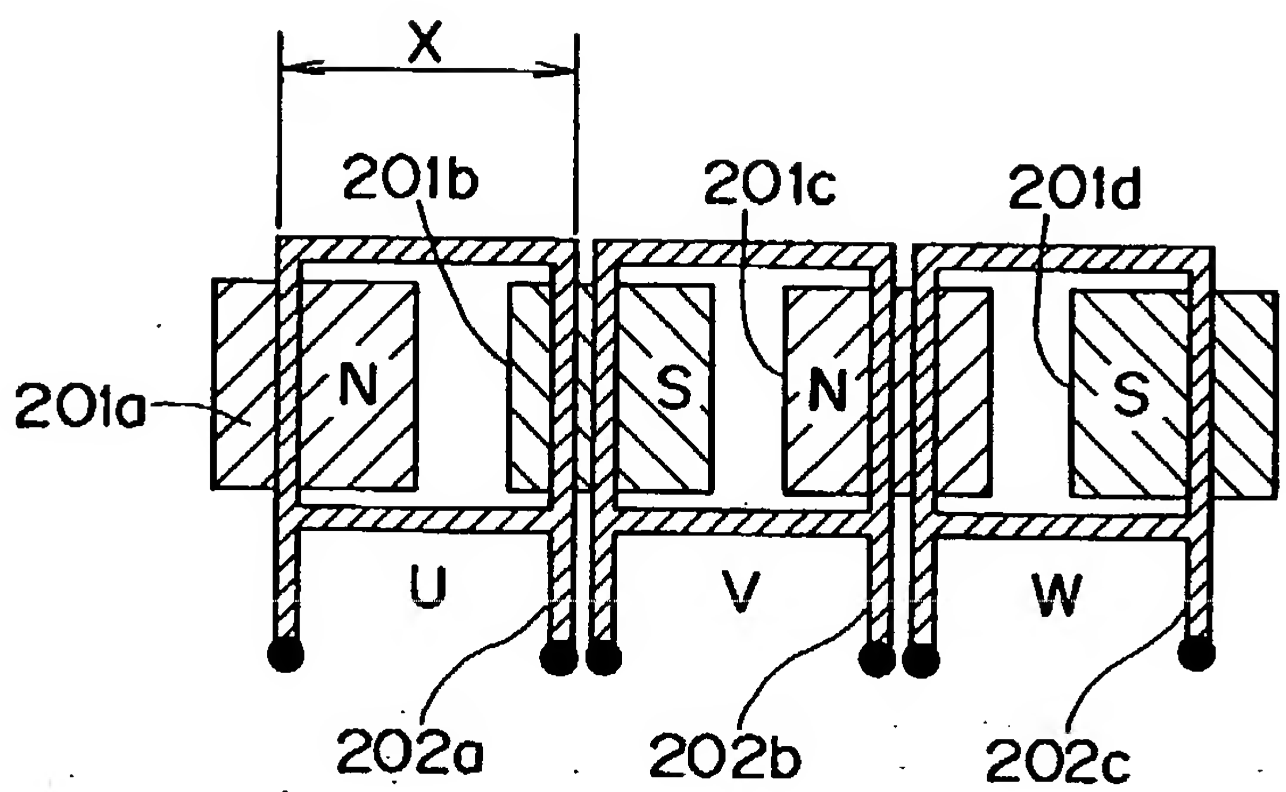
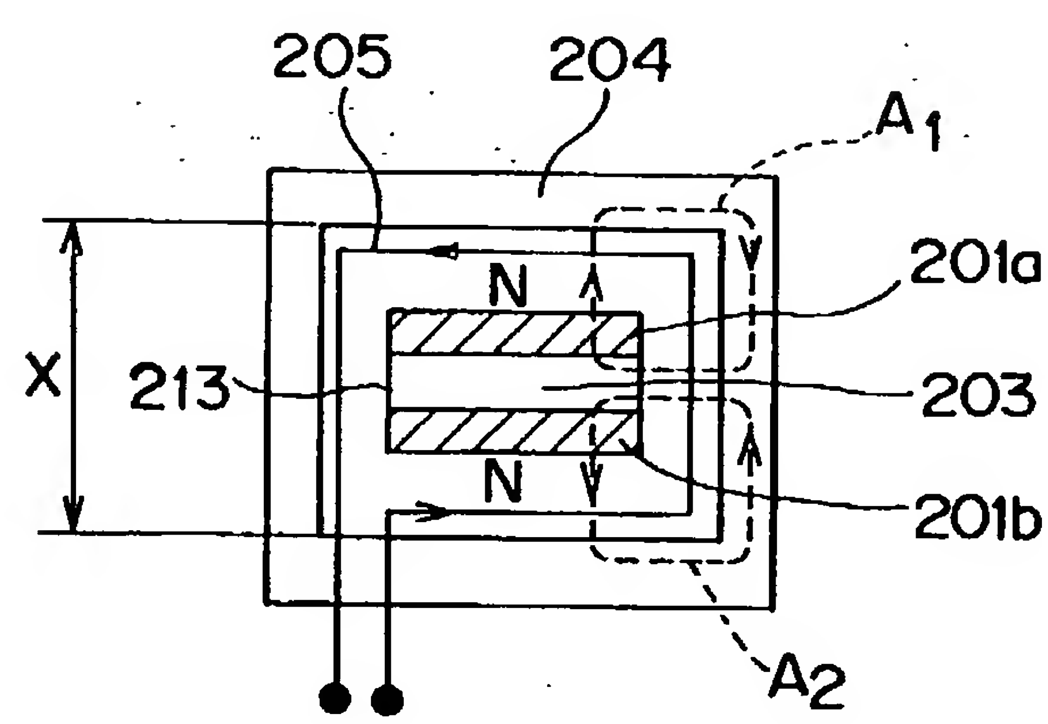

X
201b
201c
201d
201a
N
S
N
S
U
V
W
202a
202b
202c

Fig. 55


205
204
A1
201a
N
X
213
203
N
201b
A2